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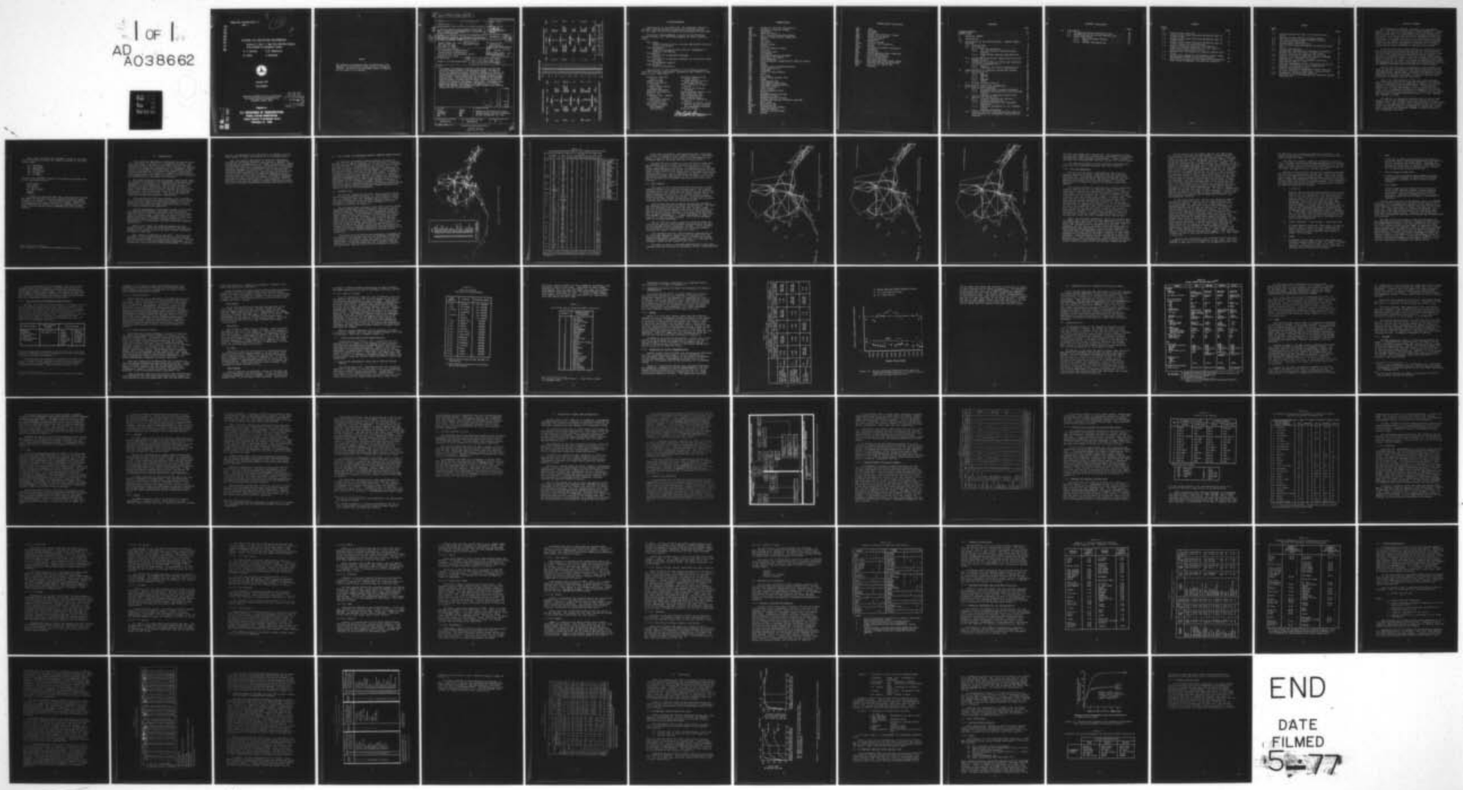

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Part I

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ALASKAN AIR NAVIGATION REQUIREMENTS

Volume II, Part I -- Near Term Benefits Analysis of the Alaskan Air Navigation System

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January 1977

Final Report

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16. Abstract

This Volume (II) presents an analysis of the problems and near-term solutions related to Alaska's Air Navigation System. The needs of the air taxi operators and major intra-state scheduled air carriers are considered based on such figures of merit as enroute navigation gaps, traffic volume, landing probabilities and candidate navigation system characteristics. The study concludes that 6 VOR/DME's and 6 NDB/DME's would be adequate to satisfy most of Alaska's near-term enroute and terminal air navigation requirements, respectively. Recommended implementation sequences are provided for each combination of candidate NAVAID (NDB, NDB/DME, VOR, VOR/DME and TACAN) and application (enroute, approach and dual--enroute/approach).

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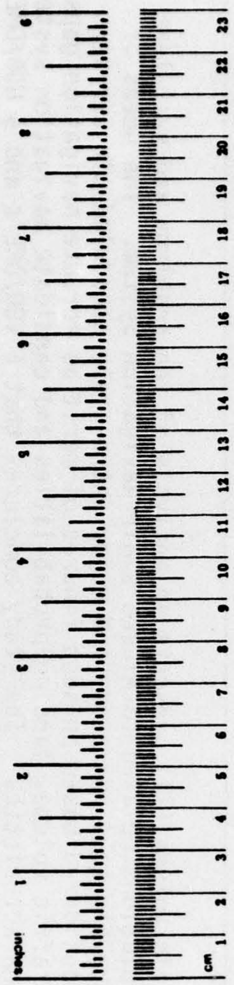
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

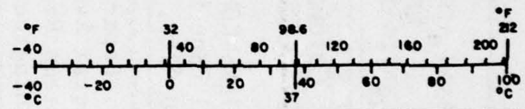
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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- SEA Airomotive, Inc.
- Sierra Research Corp.
- Tull Aviation Corp.
- United States Geological Survey
- University of Alaska, Institute of Social, Economic and Government Research
- Wien Air Alaska

Hal Solomon

Hal Solomon, Project Manager

NOMENCLATURE

AACA	Alaska Air Carriers Association
ADF	Automatic Direction Finder
ANC	Anchorage
ANN	Annette Island
ARD-300	FAA - Enroute Navigation Branch
ATC	Alaska Transportation Commission
BET	Bethel
BGQ	Big Lake
BIG	Big Delta
BKA	Biorka Island
BTT	Bettles
CAB	Civil Aeronautics Board
CDB	Cold Bay
CW	Continuous Wave
DLG	Dillingham
DME	Distance Measuring Equipment
DOD	Department of Defense
DR	Dead Reckoning
ECAC	Electromagnetic Compatibility Analysis Center
ENA	Kenai
ENN	Nenana
FAA	Federal Aviation Administration
FAF	Final Approval Fix
FAI	Fairbanks
FSS	Flight Service Station
FT	Feet
FYU	Ft. Yukon
HAA	Height About Airport (Ft)
HOM	Homer
IF	Intermediate Fix
IFR	Instrument Flight Rules
ILS	Instrument Landing System
JOH	Johnstone Point
LVD	Level Island
MAP	Missed Approach Point
MCG	McGrath
MDA	Minimum Descent Altitude
MDO	Middleton Island
MEA	Minimum Enroute Altitude
MOCA	Minimum Obstruction Clearance Altitude
MOS	Moses Lake
MSL	Mean Sea Level
NAVAID	Navigation Aid
NDB	Non-Directional Beacon
NMI	Nautical Mile(s)
OAG	Official Airline Guide
ODK	Kodiak

NOMENCLATURE (Continued)

OME	Nome
ORT	Northway
OTZ	Kotzebue
REIL	Runway End Identifier Lights
RVR	Runway Visual Range
RNAV	Area Navigation
SCC	Deadhorse
SSR	Sisters Island
TACAN	Tactical Air Navigation
TAL	Tanana
TERPS	Terminal Instrument Procedures
TKA	Talkeetna
UNK	Unalakleet
VASI	Visual Approach Slope Indicator
VHF	Very High Frequency
VFR	Visual Flight Rules
VLF	Very Low Frequency
VOR	VHF Omnidirectional Radio Range
VORTAC	Combined VOR and TACAN System
VXXX	Victor Route Number XXX
YAK	Yakataga

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FIGURES

TABLES

I. EXECUTIVE SUMMARY

The inadequacies inherent in Alaska's Air Navigation System, in the form of enroute gaps, uninstrumented air carrier airports, and lack of a comprehensive route structure, contribute to inefficient user operations and produce hardships on the public in a region that is heavily dependent on air transportation. This study of Alaska's Air Navigation System was structured to identify specific enroute and terminal approach problem areas, define and evaluate candidate near-term solutions, and finally to recommend a preferred set of remedial actions based, where possible, on benefit-cost criteria.

A lack of sufficient record keeping by Alaska's air transportation industry precluded the possibility of quantifying the resulting navigation system-induced user cost impacts and, in turn, the dollar benefits which could result from an improved air navigation system. However, Alaska's poor performance in terms of air safety (where their accident rates exceed those of the U.S. by close to an order of magnitude) and schedule dependability provides circumstantial evidence that the lack of adequate navigation facilities may be a major problem.

The air taxi operators recommended six new VOR/DME locations to provide a satisfactory near-term solution to the low altitude enroute gap problem. The Alaskan scheduled carriers (Alaska Airlines, Reeve Aleutian Airways, and Wien Air Alaska) identified 25 airports which were in need of improved (non-precision) instrument approach facilities.

Due to the unavailability of the user cost statistics associated with each of the suggested navigation aid improvements, an approach based on performance figures of merit was adopted to evaluate the candidate sites. Derivation and application of these performance criteria produced priority lists, i.e., recommended installation sequences, for both enroute and approach aid applications in combination with each of the short-term candidate navigation aids, i.e., NDB, NDB/DME, VOR, VOR/DME or TACAN.

An analysis of these data revealed that at least 6 and no more than 20 new VOR/DME's would be required to satisfy Alaska's short-term enroute low altitude navigation requirements. Further, 6 new approach aids would achieve 90 per cent of the total "performance benefit" attainable by installing a given type of approach aid (NDB/DME, VOR/DME or TACAN) at each of the recommended locations.

This study concludes that VOR/DME's should be installed at the following locations to reduce the extent of existing enroute gaps:

(1) Chandalar
(2) Sparrevohn
(3) Yakataga
(4) Port Heiden
(5) Iliamna
(6) St. Mary's

Further, that NDB/DME's should be installed as approach aids at the following airports:

Dutch Harbor
Sand Point
St. Mary's*
St. Paul Island
Togiak
Emmonak

It should be recognized that this study does not consider the impact of possible long-term solutions presently being proposed (see Volume I). The acceptance and/or implementation rates of world wide systems such as Omega, Loran-C and/or GPS/NAVSTAR will affect the need for additional "short-range" stations beyond those recommended for the near-term solution.

*Not required if a VOR/DME is installed at this location

II. INTRODUCTION

This study was undertaken to determine the optimal short-term solution(s) to Alaska's air navigation problems. The associated study, one facet of an overall project (Volume I addresses the long-term solutions), was structured to identify specific air navigation problem areas, to recommend possible remedial alternatives, to estimate the benefits that would accrue should there be a partial or complete elimination of each problem area, and finally to identify specific navigation aid installations as the short-term solution.

The study focussed on two user groups, each having specific problems with Alaska's air navigation system which, when aggregated, are believed to be representative of the total Alaskan civil user population. The air taxi operators, operating primarily non-pressurized aircraft at lower altitudes, reflected general aviation's concern over enroute navigation gaps. The second group consisted of the major CAB scheduled Alaskan air carriers. This group was primarily interested in upgrading approach capabilities.

The prevailing and near-term problem areas of Alaska's air navigation system were identified through on-site discussions with user groups, the FAA Alaskan Region, the State Division of Aviation, and other local data sources such as the Alaska Transportation Commission.

Lack of comprehensive statistical records of the Alaska Air Transportation Industry precluded the derivation of expected "dollar" benefits for each of the proposed navigation aid installations. Therefore, in lieu of a pure cost/benefit analysis, performance related figures of merit were developed in order to evaluate proposed solutions, i.e., navigation aid installations, for both enroute and approach applications.

Most of this study was conducted between July and October of 1975. Hence, with few exceptions, the data presented in this report reflects the most current information available at that time.

This volume is organized in two parts. The first part includes: (1) an identification of the near-term problems associated with Alaska's air navigation system, (2) a description of the short-term navigation system candidates, (3) an evaluation of site specific, NAVAID improvements or additions

and (4) a recommendation for the priority of NAVAID installations needed to reduce the problems to an acceptable level.

Part two contains appendices of detailed supplemental information addressing potential user benefits, updated FAA Alaskan Region recommendations for VORTAC installations, safety and scheduled departure statistics, characteristics of Alaskan airports, air taxi origin-destination statistics, ceiling and visibility minimums as a function of type of approach aid, estimated landing probabilities, distribution of scheduled air carrier traffic, derivation of community dependence on air transportation factors, descriptions of candidate navigation aid locations and a statistical summary of avionics equipment installed on Alaska-based aircraft. This material, much of which is in the form of computer produced tabulations, should be useful to Alaska transportation planners and airspace users.

III. THE ALASKAN AIR NAVIGATION SYSTEM - PROBLEM IDENTIFICATION

To identify and properly weigh potential solutions to Alaska's air navigation problems, it was necessary to develop an understanding of the inadequacies of the existing system and the impact of those inadequacies on the airspace users. The material presented in this section addresses coverage gaps in the current airway structure and the impact of the Alaskan air navigation system on its users, both with respect to enroute coverage and non-precision approach capabilities. Finally, a comparison between Alaskan and U.S. air safety and scheduled departure dependability is made as an indicator of the relative performance of the Alaskan air transportation system and, by inference, the air navigation system. However, it should be emphasized that a quantified relationship between the navigation system performance and the safety and schedule dependability statistics has yet to be established.

3.1 COVERAGE GAPS

The present Alaskan low altitude route structure including existing navigation facilities is illustrated in Figure 3.1. To simplify this plot, designations of specific Victor and colored routes were not included; however, Table 3.1 can be used to correlate the Victor route designator with the navigation facilities of Figure 3.1.

The navigation gaps prevalent within this existing Alaska navigation system were first determined. The entire Victor airway system was superimposed on the Geological Survey contour map of Alaska. Electromagnetic Compatibility Analysis Center (ECAC) terrain data was used to determine the line-of-sight cutoff at various altitudes. The altitudes selected were 3,000 ft above the site elevation, 8,000 ft MSL and 13,000 ft MSL since these were obtained directly from the ECAC data without further interpolation. The regulatory range limit of 40 nmi below 18,000 ft was disregarded since its primary objective, frequency protection, is, in general, not a problem in Alaska thereby enabling the VOR/DME facilities to be utilized to their maximum (terrain or horizon cutoff) capability.

Where ECAC terrain data was not available or appeared to be inaccurate (as was the case for the Fairbanks and McGrath facilities), the terrain cutoff for a given Victor route was determined by using the contours printed on the Geological Survey map. If terrain cutoff was not a problem, then the horizon cutoff limit was used for the altitudes of interest.

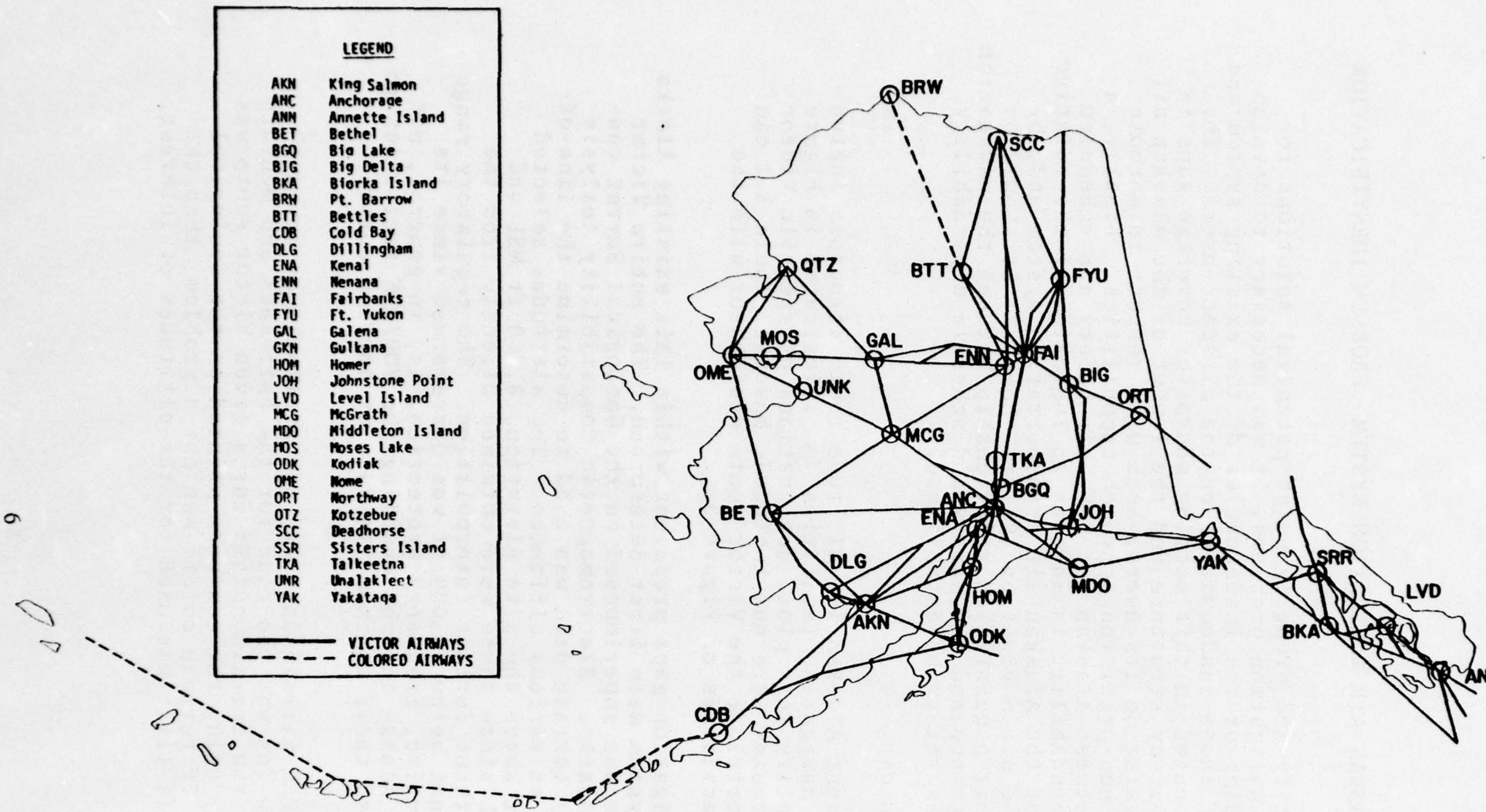

Figure 3.1 Alaska Airway Structure

Table 3.1
Existing Navigation Gaps in the Alaska Victor Airway

ROUTE SEGMENT END POINTS		VICTOR ROUTE	GAP (NMI)			MEA (MSL)
			3,000' ASL(1)	8,000' MSL	13,000' MSL	
AKN	ANC	V427	120	36	---	13,500
	CDB	V456	145	78	15	NA
	ENA	V456	80	16	---	12,500
	HOM	V436	72	---	---	NA
	ODK	V506	35	---	---	9,500
ANC	BGQ	V438,456	---	---	---	NA
	JOH	V317S	31	---	---	NA
	JOH	V317	9	---	---	NA
	MCG	V440	93	24	---	NA
	MDO	V440S	40	---	---	NA
	MDO	V440	66	---	---	NA
	TKA	V436	---	---	---	NA
ANN(2)	LVD(2,3)	V317	---	---	---	5,200
BET	AKN	V506	62	---	---	7,000
	ANC	G-9(6)	197	138	77	(4)
	DLG	V453	32	---	---	6,000
	MCG	V480	120	50	---	5,500
BGQ	MCG	V510	58	8	---	NA
BIG	GKN	V481	27	---	---	NA
	GKN	V515	36	20	---	NA
	ORT(2)	V444	---	---	---	NA
BKA(2)	ANN(2)	V307	66	---	---	5,500
	SANDSPIT(2)	V440	108	42	---	3,500
	SSR(2)	V428	16	---	---	NA
BTT(2)	ENN	V504	22	---	---	NA
	SCC(2)	V504	114	20	---	NA
DLG	AKN	V453,453S	---	---	---	NA(5)
	ANC	V462	130	60	---	13,500
ENA	ANC	V436,456	---	---	---	NA
	MDO	V508,440S	47	---	---	8,500
ENN	SCC(2)	V436	210	132	90	NA
	TKA(2,3)	V436	---	---	---	NA
FAI	BGQ	V438	105	38	---	NA
	BIG	V444	---	---	---	NA
	BTT(2)	V444,444S	---	---	---	NA
	ENN	V480	---	---	---	NA
	FYU(2)	V438	---	---	---	NA
	SCC(2)	V347	180	120	70	NA
	TAL(2,3)	V488	---	---	---	NA
FYU	BIG	V481	10	---	---	NA
	SCC(2)	V438	88	27	---	9,500
GAL	ENN	V452	71	---	---	NA
	MOS(2,3)	V452	---	---	---	5,500
	OTZ(2)	V498	44	---	---	5,500
	TAL(2,3)	V488	---	---	---	NA
GKN	BGQ	V456	33	---	---	NA
	JOH	V481	56	8	---	NA
	ORT(2)	V456	35	12	---	NA
HOM	ANC	V438	---	---	---	NA
	ENA	V436E	---	---	---	NA
JOH	GKN	V481E	48	10	---	NA
	YAK(2)	V317	105	23	---	NA
MCG	ENN	V480	97	35	---	4,500
	GAL	V498	---	---	---	5,500
	UNK	V440	32	---	---	5,500
ODK	HOM	V438,438W	---	---	---	5,500
OME	BET	V506	95	10	---	3,000
	GAL	V452	---	---	---	5,500
	OTZ(2)	V506,506W	---	---	---	5,500
	UNK	V440	---	---	---	2,500
SSR(2)	LVD(2,3)	V317	---	---	---	NA
	YAK(2)	V317	28	---	---	2,000
YAK(2)	BKA(2)	V317,440	60	---	---	4,800
	MDO	V440	76	---	---	7,500

AKN	King Salmon
ANC	Anchorage
ANN	Annette Island
BET	Bethel
BGQ	Big Lake
BIG	Big Delta
BKA	Biorka Island
BTT	Bettles
CDB	Cold Bay
DLG	Dillingham
ENA	Kenai
ENN	Nenana
FAI	Fairbanks
FYU	Ft. Yukon
GAL	Galena
GKN	Gulkana
HOM	Homer
JOH	Johnstone Point
LVD	Level Island
MCG	McGrath
MDO	Middleton Island
MOS	Moses Lake
ODK	Kodiak
OME	Nome
ORT	Northway
OTZ	Kotzebue
SCC	Deadhorse
SSR	Sisters Island
TAL	Tanana
TKA	Talkeetna
UNK	Unalakleet
YAK	Yakataga

(1) ASL - Above Site Level; (2) ECAC Data Not Available; (3) VOR Only; (4) 5,500 ft (MSL) West of Alaska Range, 12,500 ft (MSL) Above Alaska Range; (5) NA - Not Available; (6) G-9 Is Included Because of Heavy Traffic Between Anchorage and Bethel and the Absence of a Victor Route Serving That Community Pair.

Using these procedures, the navigation gaps illustrated in Figures 3.2 through 3.4 and listed in Table 3.1 were determined. Also recorded on this table are the Minimum Enroute Altitudes (MEA) as obtained from the sectional charts.

The gaps defined in Table 3.1 are for Victor routes only and therefore do not include coverage provided by existing NDB's. An exception is route G-9. The absence of a Victor route between Anchorage and Bethel in combination with the high traffic level between those points justified inclusion of that route in Table 3.1. G-9 is supported by a DOD NDB at Sparrevohn approximately midway between Anchorage and Bethel. This route and others providing NDB signals on the Aleutian chain should not be construed as an adequate substitute for Victor route coverage.

3.2 USER IMPACTS

The scope of this study necessiated focusing on a representative subset of all Alaska airspace users. This subset included the air taxi operators represented by the Alaska Air Carriers Association (AACA) and the larger Alaskan CAB certificated scheduled air carriers, i.e. Alaska Airlines, Reeve Aleutian Airways, and Wien Air Alaska. Aviation representatives of the Trans Alaska Pipeline Project were also surveyed regarding their *near-term* air navigation needs.

The aircraft that are in use by the air taxi operators are primarily single and twin engine configurations. The major air taxi operators have at least one twin in their fleet. There is an increasing demand on the part of the customer for the safety and comfort benefits of the twin engine aircraft. Most of the twin engine aircraft are equipped with dual ADF's and VOR/DME's (Appendix K). A small percentage of these aircraft (5 to 10%) are RNAV equipped. Very few are equipped with VLF or Omega equipment.

The air taxi user group, primarily operating these non-pressurized aircraft, have problems associated with the lack of low altitude enroute navigation coverage. These problems are considered to be representative of the larger general aviation user group of which they are a part.

The scheduled carriers, using primarily pressurized jet or turbo-prop equipment, appeared to be satisfied with the high altitude enroute coverage. Their problems were concentrated on improving approach capabilities, i.e. lowering the minimums at many of the airports they serve.

In order to obtain a thorough understanding of the users' problems with the existing air navigation system, representatives

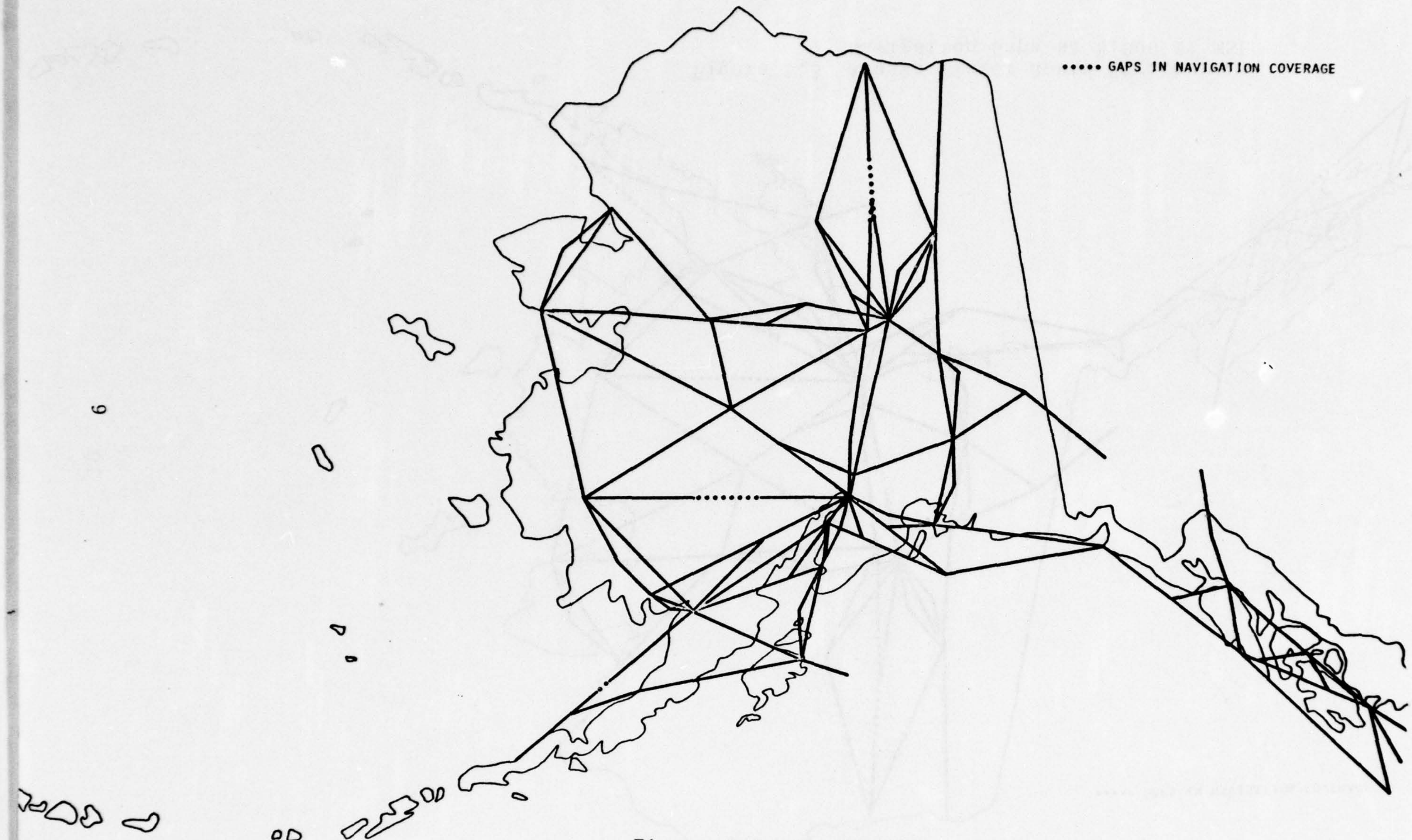

Figure 3.2 Alaska Victor Route Structure Navigation Gaps at 13,000 ft MSL

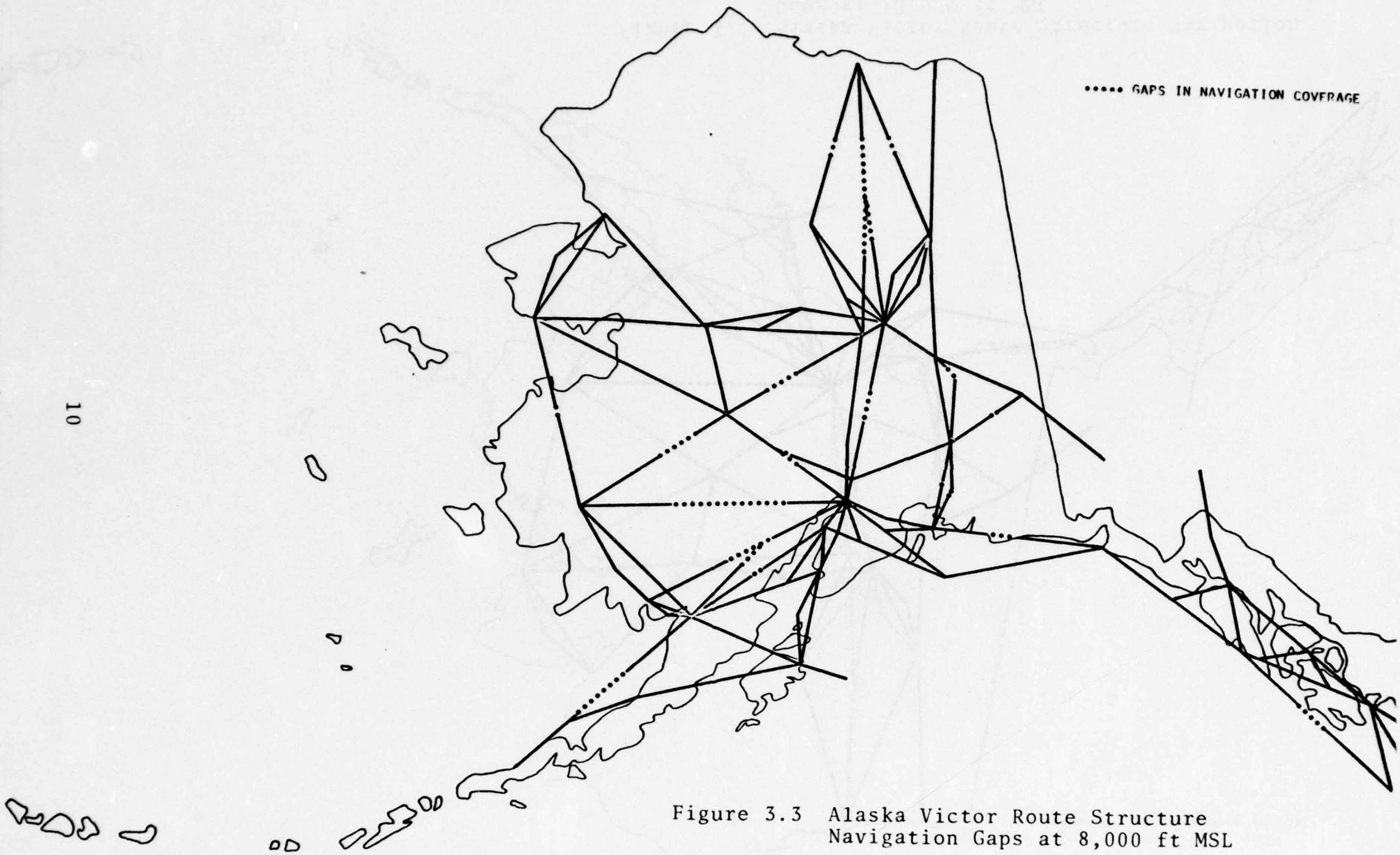

Figure 3.3 Alaska Victor Route Structure
Navigation Gaps at 8,000 ft MSL

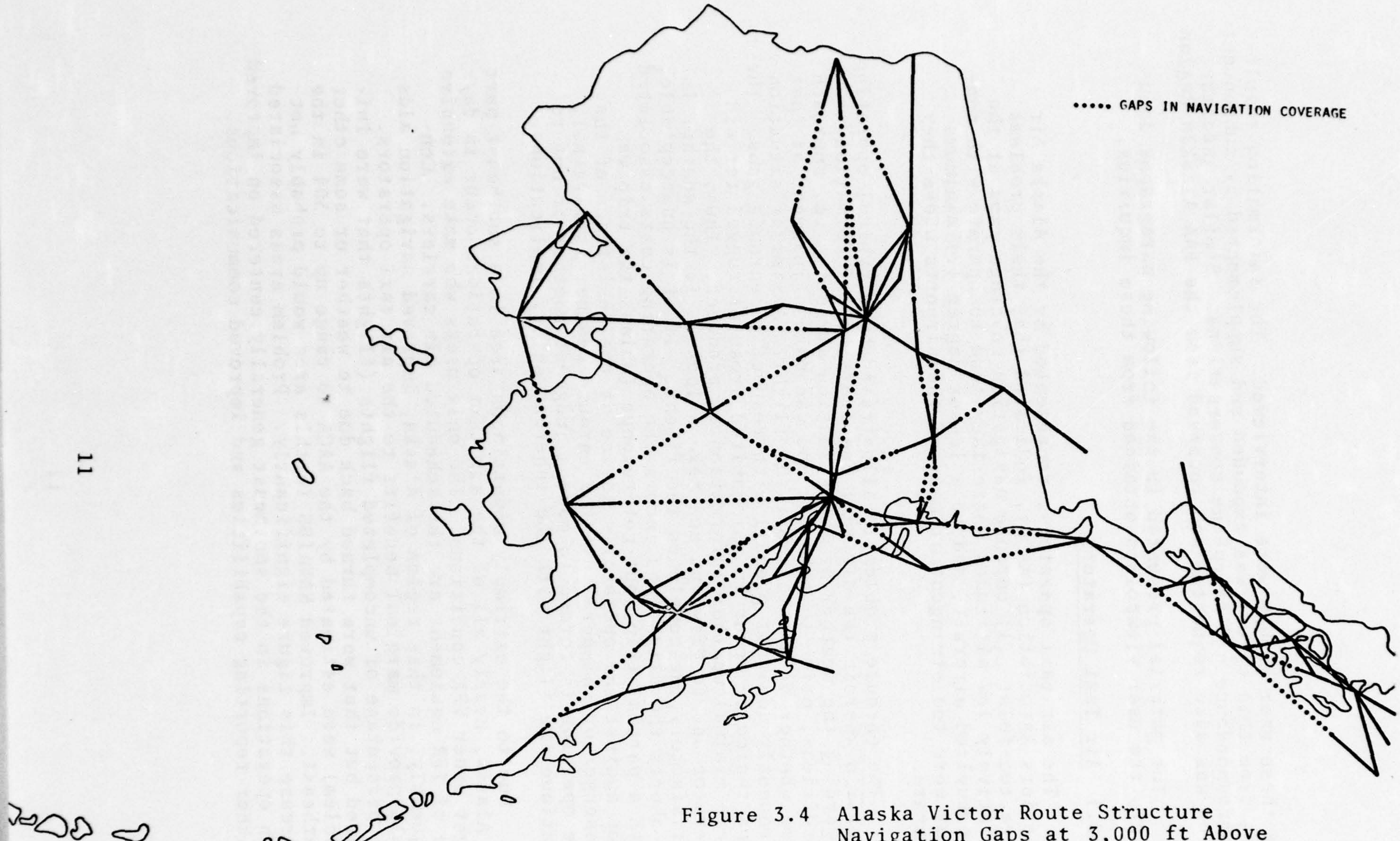

Figure 3.4 Alaska Victor Route Structure Navigation Gaps at 3,000 ft Above the Site Elevation

of these user groups were interviewed. The information resulting from this effort was expanded and supplemented by subsequent correspondence and telephone conversations. Similar information was also requested and received from the FAA Alaskan Region.

The material presented in the following paragraphs documents the user viewpoints obtained from these inquiries.

3.2.1 Air Taxi Operators

The air taxi operators, represented by the Alaska Air Carriers Association (AACA), indicated that their problems were two-fold: (1) enroute navigation coverage gaps at the relatively low altitudes where they tend to operate with non-pressurized aircraft, and to a lesser degree (2) minimums that were too stringent at many of the airports where they operate.

The enroute problem is illustrated by a typical operating scenario wherein the air taxi operators have information regarding the weather at a destination airport, i.e. approach conditions, prior to take off and can make a judgment at that time whether or not to abort the flight. A similar situation frequently does not prevail with respect to enroute gaps. These gaps typically occur in uninhabited areas of rugged terrain where minimal weather information is produced. Thus, the operator has to "fly out and take a look." If the weather is satisfactory, he completes the flight. If it is unacceptable, he aborts the flight and incurs the operating costs associated with a partial trip, but not revenue (unless the trip was made against the operator's advice at the insistance of the passenger or shipper). If the enroute weather is marginal, the operator is forced to make a judgment whether or not to continue the flight with the inherent safety implications.

Due to the extremely mountainous area in a southeast part of Alaska, nearly all of the air taxi operations occur in daylight under VFR conditions. The only users who make extensive use of IFR equipment are the scheduled air carriers. Consequently, in this region of Alaska, improved navigation aids would provide marginal benefits to the air taxi operators. The percentage of uncompleted flights (flights that were initiated but that were turned back due to weather or some other problem) were estimated by the AACA to range up to 30% in the southeast. Improved NAVAIDS in this area would probably not decrease this figure significantly. Problem areas associated with operations in the southeast generally centered on improved weather reporting capabilities and improved communications.

In the central part of Alaska, the air taxi operations are generally concerned with the movement of passengers and cargo from the hub cities to the outlying villages. These hub cities include places like Anchorage, Bettles, Bethel, Cordova, Fairbanks, McGrath, etc. The NAVAID facilities in these hub cities are characterized by VORTAC and/or ILS. However, in the regions surrounding these hub cities, many small airports have virtually no instrument approach aids. A few of the air taxi operators in this region have RNAV equipment; however, for approach applications this equipment works satisfactorily only within 25 miles of the VORTAC station due to line-of-sight limitations. The approach procedure that is most often used at the present time in this region is flying IFR from the origin to the radio facility that is nearest the destination, making the descent on instruments over the facility until the aircraft is below the overcast, and then proceeding VFR to the destination airport. At other times, it is necessary to fly above the overcast for a specified distance, past a NAVAID whose location is estimated by ground speed computations, and then to descend through the overcast near the airfield. Of course, unknown wind factors can degrade the safety of this procedure. It was stated that one potential use of DME in these procedures would be the determination of accurate ground speeds and distances from the navigation facility.

In the North Slope area, the air taxi operators support specialized interests such as the oil exploration and oil drilling operations. The high cost of down time for these operations makes reliable air service almost mandatory. A general measure used is that the typical cost of down time for drilling rigs is one dollar per second. One of the severe visual approach situations in the North Slope area concerns the "whiteout" conditions that can exist in that area. These conditions produce a problem of horizon definition. Navigation coverage is needed under these conditions, even though there may be no ceiling or visibility problems, in the classic sense, because of the lack of visual landmarks in flat, snow-covered landscapes. Another problem in operating the North Slope area is caused by the poor signal propagation characteristics attributable to frozen ground and snow. In these areas, during the winter time, the useful range of an NDB is often limited to 10 or 20 miles. Under these circumstances, finding airports beyond this range, in IFR conditions, without the use of more sophisticated NAVAIDS, i.e., VOR, TACAN, is difficult.

The air taxi operations in the Aleutian Islands generally supplement the air carrier operations in that area. The major problem in that area is the number of uncompleted flights that

are caused by low ceiling and visibility conditions. The primary requirement for new NAVAIDS in this area would be to reduce landing minimums.

The AACA was, however, unable to establish a priority list of airports which required enhanced approach aid capabilities. Further, they recognized the improbability of the FAA supplying large quantities of non-precision approach aids to "air taxi" (as opposed to air carrier) airports.

Because of these factors the air taxi operators narrowed the near-term air navigation problem areas, which they would like to see remedied to six enroute gaps. They would prefer to see these gaps filled through the installation of six VOR/DME's, rather than NDB/DME's, because of preceived inadequacies of NDB's when used in the Alaska environment. The priorities and supporting rationale for these six facilities as defined by this user group are as follows:

1. St. Mary's

   Both St. Mary's and the Taylor Mountain sites would provide for IFR capabilities that currently do not exist in an area served by 27 air taxi operators plus at least five other carriers flying regularly between points in this area and Fairbanks and Anchorage. These air taxi operators made about 35,008 flights, carrying 94,935 passengers, 4.6 million pounds of freight and 1.2 million pounds of mail in 1974 according to reports filed with the Alaska Transportation Commission (see ATC Summary of Calendar Year 1974 Southwest figures in Appendix A). A St. Mary's facility would also close a "gap" and, at the same time, provide IFR capabilities in a very large and busy section of the State at the delta of the Yukon River.

2. Taylor Maountain - Lime Village - Sparrevohn Area

   A Taylor Mountain facility, about equal in priority with St. Mary's, would give new coverage on the Anchorage-Bethel route, at under the 10,000 ft level, where a "gap" in NAVAIDS exists which is almost 175 miles long.

3. Kobuk

   No NAVAID, even an NDB, exists in the Kobuk area. Distance between nearest 2 VOR's is almost 275 nautical miles. There are at least 12 air taxi firms based in and around this area, plus a great deal of seasonal mineral exploration activity.

4. Umiat

A facility at Umiat would provide an aid north of the Brooks Range, half-way between Barrow and Bettles, which is south of the Brooks Range. Although not filling the signal gap, it would at least make available an aid in an area of unusual activity because of oil and mineral-related activities.

5. Beaver-Stevens Village Area

A Beaver facility would provide needed aid along a route heavily traveled in connection with energy development in Alaska, as well as other regular commerce.

6. Port Heiden

A Port Heiden facility would provide an aid on a route to the Aleutian Islands, a route becoming increasingly active because of energy-related activities. Additional comments by the air taxi operators supporting their request is presented in Appendix A.

The AACA believed that the building of these six VOR/DME facilities could be done using the very latest solid state technology at a substantially reduced cost (discounting inflation) relative to the costs of similar facilities built a few years ago. They urged that all stations be unmanned, low-power type, exploring the possibility of using solar and/or wind power as an energy source. Reducing site preparation costs was considered by the AACA in selecting the aforementioned six locations.

The AACA stated that safety is the one area which has been compromised because of Alaska's inadequate NAVAID system. The demand made on Alaska's air taxi industry by the public for vital transportation services makes it imperative that every possible trip be completed, least freight and passengers become backlogged, resulting in extra push during periods of good weather. This need to get the job done, in response to public pressure to move goods and/or passengers without substantial delays, is believed to be a contributing factor to Alaska's high accident rate. In the AACA's judgment, the six facility locations recommended herein would result in a significant improvement in Alaska's air safety record.

It was also pointed out by the AACA, that pilots being trained today take for granted a sophisticated navigation systems and aircraft manufacturers build and equip aircraft to be used on these airway systems. In Alaska, the operators are finding it increasingly difficult to find pilots who are able to "fly by the seat of their pants" and the AACA belives that this requirement should not be necessary.

3.2.2 CAB Certificated Scheduled Alaska Carriers

Meetings were held with representatives of Alaska Airlines, Reeve Aleutian Airways and Wien Air Alaska to identify each of their unique problems with respect to Alaska's air navigation system. All seemed satisfied with the existing enroute facilities (reflecting their high altitude operations) and dissatisfied with the approach aids. The problem is so serious that each has found it necessary to supplement the FAA's approach aid system by installing and maintaining their own NDB's at the following locations:

ALASKA AIRLINES	REEVE ALEUTIAN AIRWAYS	WIEN AIR ALASKA	
Wrangell Petersburg Sitka (Localizer Back-Up) Cordova (Currently Shut-Down)	Sand Point (2) St. Paul Is. (2)	Aniak Chevak Emmonak Gambell Holy Cross Hooper Bay Kipnuk Kobuk	Mokeryuk Platinum Point Hope Quinhagek Savoonga St. Mary's Tooksook

Privately-owned Microwave Landing Systems have been also considered at Bethel*, St. Mary's, Deadhorse*, Aniak, Dillingham, Kotzebue, Petersburg and Wrangell.

These carriers each operate in different sections of the state. Alaska Airlines operates primarily in the southeast section as well as providing direct service from Seattle to Anchorage and Fairbanks. Reeve operates primarily from

*Prior to the FAA's installation of ILS's at these locations

Anchorage to the Aleutian chain, while Wien operates from Anchorage and Fairbanks to the west coast and North Slope. Due to these diverse areas of operation, the three carriers have different navigation problems.

3.2.2.1 Alaska Airlines

Alaska Airlines is in the process of converting to an all 727 fleet. Such a conversion is predicated upon the ability to provide service with that type of aircraft to the communities of Petersburg and Wrangell. Advocates of this change point out that, if implemented, this service would not only facilitate a more efficient air carrier operation (see Appendix A), but would permit direct single aircraft freight shipments from Seattle, Anchorage and/or Juneau to Petersburg and Wrangell, thereby eleminating the time and cost factors associated with transferring each shipment from a 727 to the Twin Otters which formerly served Petersburg and Wrangell. Thus, Alaska Airlines' NAVAID requirements are located in southeastern Alaska, where they have a need to reduce the ceiling minimums to something less than 1,000 ft at both Petersburg and Wrangell, in order to ensure dependable 727 service.

3.2.2.2 Reeve Aleutian Airways

Reeve Aleutian Airways operates a variety of large prop and turbo-prop equipment into a number of airports on the Aleutian Island chain. The weather experienced along these routes is claimed to be some of the worst in the world. Their major operational problem concerns operating their large aircraft into airports that have few or no approach NAVAIDS. Schedule reliability at these airports is poor due to the high approach minimums. In particular, they would like to see improved navigation aids at Port Heiden, Sand Point, Dutch Harbor, and St. Paul Island. Reeve claims that 8 cancelled flights out of 29 scheduled for one month at St. Paul Island cost them $129,600 (details presented in Appendix A). Reduced landing minimums at these airports could conceivably save Reeve Aleutian many thousands of dollars each year.

Reeve has continually requrested the FAA to install letdown and enroute navigational aids along their routes. Except for the Cold Bay station, the FAA has done nothing due to the number of other requests that were given higher priority. Consequently, Reeve is forced to continue to operate with World War II non-directional beacons, high MDA's, etc.

Reeve maintains that while the need for more sophisticated aids probably is not great when based upon traffic volume, aircraft operations and area population, they are reasonable when

operating efficiency, community requirements, schedule reliability and safety are considered.

With the advent of sophisticated turbine powered equipment, a few years ago, Reeve believes that newer and more modern NAVAID facilities are needed to ensure some sort of reliability of service. The following are examples of four stations served by Reeve aircraft, the letdown facilities available and Reeve's comments on what is needed.

Port Heiden

Serves the Peninsula area plus all the stations on the south side. The area is flat. LOC/DME, VORTAC or TACAN type equipment would allow minimums of at least 300 ft and 3/4 nmi. Better enroute aids, i.e., VORTAC/TACAN, are needed, especially in lower altitude range, surface to 12,000 ft. Much development in this area is forecast in the coming years. Mineral and oil exploration is increasing anually. This area is served by YS-11, C-46, DC-6 and, starting this winter, L-188 aircraft.

Sand Point

One of Reeve's higher density stations. Reeve installed two NDB's at San Point last summer to establish an approach which helps, but it is still marginal. The approach should be from the northwest. Newer and more modern aids would allow this and could provide minimums of 400 ft and 3/4 nmi, with a much greater safety factor. Sand Point is one of the largest fishing communities. Establishment of a community of 2,500 people is contemplated within 3 years at Balboa Bay, 30 miles away, due to large copper discoveries.

St. Paul

Home of the only fur seal activity in the United States. Tourist traffic during summer months is increasing by leaps and bounds each year. Missed trips due to fog season cause great economic hardship (details in Appendix A). A VOR has been programmed by the FAA Alaskan Region for years, but continually denied. TACAN/VORTAC would serve as an enroute aid to international traffic and allow for lower minimums, safer operation and more reliable service.

Dutch Harbor

Largest community in Aleutians, center of the King Crab industry, employing 1,000 plus workers. There are nine crab processing companies at this location. No aids exist at the present time. It is strictly a VFR operation. Installation

of VORTAC or TACAN equipment would allow for more reliable and safer operation in an area of extremely difficult terrain.

3.2.2.3 Wien Air Alaska

Wien Air Alaska has found the lack of NAVAIDS at many of the airports they serve to be critical enough to justify the installation and operation of their own NDB's. These NDB's give them some measure of navigation coverage throughout most of their service area. However, they would like to have a facility at St. Mary's which would improve both the enroute coverage and the approach situation at that airport. Another problem area for Wien concerns the hub airport to outlying area traffic. Instrument approach procedures are generally adequate at the hub airports; however, from there passengers and cargo can travel to the outlying airports only in VFR conditions, due to the lack of NAVAIDS at these airports. Consequently, operations at the hubs are often hampered by lack of ability to get aircraft in and out of the outlying airports. In particular, the cost of housing and feeding the passengers on these delayed flights creates an economic hardship upon the company.

Wien Air Alaska supplied a list of stations, in order of priority, together with the type of NAVAID support they feel is necessary. This list is shown in Table 3.2.

3.2.3 Trans-Alaska Pipeline and Roads Projects

Representatives of Bechtel, Inc., responsible for air transportation in support of the pipeline project indicated that they are satisfied with the NDB/DME system they have installed for the construction phase. However, they indicated that higher powered beacons might have been a wiser choice. Grounding is a problem which necessitated laying out 35 copper spokes at lengths of 500 ft. Even then, the ranges were only 10 or 15 miles. An adequately equipped airport on either side of the Brooks Range was the only long-term NAVAID-related need identified.

3.3 NAVIGATION REQUIREMENTS IDENTIFIED BY THE FAA ALASKAN REGION

The Alaska Region FAA, supplementing the user viewpoints addressed in Section 3.2, was the final source of information focusing on NAVAID-related requirements. In September of 1972 the region issued a memorandum entitled, "VORTAC Review - Phase Three," in which 30 locations are identified with associated justification for VORTAC installations at those sites.

Table 3.2
Wien Air Alaska
Approach Aid Requirements

WIEN PRIORITY	LOCATION	REQUESTED NAVAID
1 (b)	Kotzebue	ILS, VOR/DME
2 (b)	Dillingham	ILS, VOR/DME
3 (a)(b)	St. Mary's	ILS, VOR/DME
4	Unalakleet	ILS, VOR/DME
5 (a)(b)	Aniak	ILS, VOR/DME
6	McGrath	ILS, VOR/DME
7 (a)	Hooper Bay	VOR/DME
8 (a)	Emmonak	VOR/DME
9 (a)	Gambell	VOR/DME
10 (a)	Savoonga	VOR/DME
11 (a)	Holy Cross	VOR/DME
12 (a)	Point Hope	VOR/DME
13 (a)	Mekonyuk	VOR/DME
14 (a)	Tooksook	VOR/DME
15 (a)	Kwinhagak	VOR/DME
16 (a)	Platinum	VOR/DME
17 (a)	Kobuk	VOR/DME
18 (a)	Kipnuk	VOR/DME
19 (a)	Chevak	VOR/DME

(a) Wien currently operating their own NDB's at this station

(b) Wien previously considered using the Boeing MLS at this station

This list, shown in Table 3.3 (less Deadhorse and Barrow), was originally used in this study. Just prior to draft report publication, this list was superseded by a new set of VORTAC requirements extracted from the "FAA Alaska Regional Operations Plan," dated July 27, 1973. A review of these changes (see Appendix B) indicated that they would not significantly alter the results of this study.

Table 3.3

FAA Alaska Region Proposed VORTAC Locations*

PRIORITY	PROPOSED VORTAC SITE LOCATION
1	St. Mary's
2	Sparrevohn
3	St. Paul Island
4	Haines
5	Barter Island
6	Chandalar
7	Cape Newenham
8	Cape Spencer
9	Yakataga
10	Cordova
11	Iliamna
12	Puntilla Lake
13	Sagwon
14	Wien Arctic Village
15	Bornite
16	Umiat
17	Wainwright
18	Aniak
19	Summit
20	Minchumina
21	Lonely
22	Stevens Village
23	Cape Lisburne
24	Adak Island
25	Amchitka
26	Nikolski
27	Port Heiden
28	Cape Sarichef

*FAA Alaskan Region VORTAC Review - Phase Three, dated 11 September 1972.

Additional rationale supporting the recommended NAVAID site locations is included in Appendix J.

3.4 COMPARISON OF ALASKA AIR SAFETY AND SCHEDULED AIR SERVICE DEPENDABILITY

An overall United States to Alaska comparison of these two statistical parameters was developed to explore user statements (Section 3.2 and Appendix A) regarding the relatively poor safety and scheduled service dependability records by Alaska's air transportation system. These results provide some indication of the latent benefits that could be achieved by upgrading Alaska's air transportation system, including the air navigation system component, to a level comparable with that currently attained in the lower 48 states.

3.4.1 Safety

While it is true that factors other than the relative adequacy of the air navigation system contribute to air safety, it is still useful to examine air safety statistics in order to ascertain if improved air navigation aids could at least be partially warranted on an air safety basis. When total accident, fatal accident, and fatality rates of Alaska air service are compared with the corresponding safety records produced by comparable service in the U.S., it is found that the Alaskan rates exceeded those of the total U.S. by about an order magnitude. Table 3.4 summarizes this information which was derived from the detailed data presented in Appendix C.

Although it is difficult to quantify, Alaskan users do not believe it unreasonable to assume that at least a portion of this difference can be attributed to the dominant use of ADF/NDB in Alaska versus the use of a VOR and/or VOR/DME navigation system in the lower 48 states.

3.4.2 Scheduled Air Service Dependability

Another useful figure of merit for assessing the efficiency of an air transportation system is service dependability. This parameter, again like safety, is not wholly attributable to, but nevertheless is considered by Alaska users to be related to, the capabilities of the prevailing air navigation system.

Figure 3.5 illustrates the per cent scheduled departures not completed, a measure of service undependability, for the Alaska CAB certificated route air carriers, the U.S. local service certificated route air carriers and the U.S. trunk certificated route air carriers. The annual and individual

Table 3.4

Accident Rate Comparison

		TOTAL ACCIDENTS		FATAL ACCIDENTS		FATALITIES	
		PER MILLION A/C MILES	PER 100,000 A/C HOURS	PER MILLION A/C MILES	PER 100,000 A/C HOURS	PER MILLION A/C MILES	PER 100,000 A/C HOURS
Certificated Route Carriers (All Operations, 1964-1974)	U.S.	0.026	DATA NOT AVAILABLE	0.004	DATA NOT AVAILABLE	0.109	DATA NOT AVAILABLE
	Alaska	0.570		0.076		1.614	
Certificated Route Carriers (All Scheduled Service, 1964-1974)	U.S.	0.025	0.968	0.004	0.151	DATA NOT AVAILABLE	DATA NOT AVAILABLE
	Alaska	0.500	8.746	0.068	1.192		
Air Taxi (All Operations, 1969-1974)	U.S.	DATA NOT AVAILABLE	6.430	DATA NOT AVAILABLE	1.34	DATA NOT AVAILABLE	4.42
	Alaska		18.340		2.58		6.63

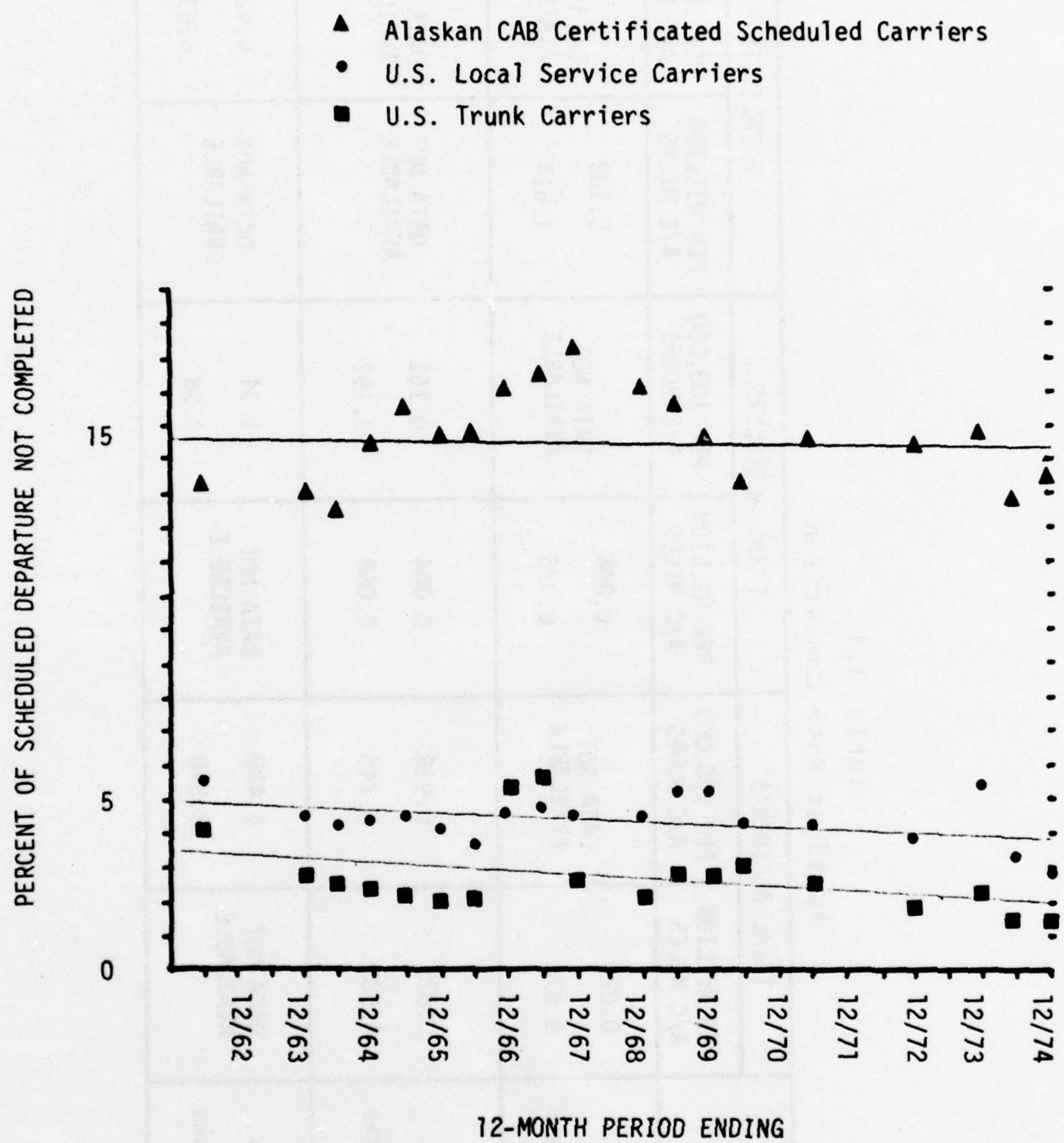

Figure 3.5 Percent Scheduled Departures Not Completed Comparison Between Alaskan Air Carriers and U.S. Local Service and Trunk Carriers

carrier data, from which the statistics illustrated in Figure 3.2 were derived, may be found in Appendix C. An examination of Reeve Aleutian's per cent scheduled departure completion record points out the need for more sophisticated NAVAIDS on the Aleutian chain. The Alaska carrier "undependability" is from three to four times that of the local service carriers and four to eight times that of the trunk carriers. Further, the rate of improvement (based on a least squares fit of the CAB data points) appears to be slower for the Alaska air carrier group than for either of the other two user groups.

IV. CHARACTERISTICS OF CANDIDATE NAVIGATION SYSTEMS

This section summarizes the characteristics of the candidate navigation systems considered in this study as potential short-term solutions to Alaska's Air Navigation problems. The characteristics include cost, coverage, accuracy, reliability, maintenance, power requirements, accessability, and siting requirements. The data has been gathered from FAA Headquarters, the FAA Alaskan Region Office, manufacturers, air carriers, air taxi operators, and pilot comments. These data reflect those current and projected values available at the time of this study, and should be modified as more current information becomes available. The pilot input is considered to be valuable in that it provides insight to actual system performance in the field and could conceivably be the basis of assessing the relative feasibility of a particular system. The data is presented in the form of a table with associated narrative.

4.1 CHARACTERISTICS

The characteristics of the candidate navigation systems (NDB's, NDB/DME's, VOR/DME's and TACAN) are shown in Table 4.1, and represent a summary of all the best data available concerning these systems as of the date of this study. Although it would be desirable to compare these systems according to some prespecified regulatory standard, it becomes virtually impossible, in light of the unique characteristics peculiar to the Alaska region. A primary difficulty in evaluating the attributes of the various systems is assessing the problem associated with siting the ground facilities. This problem does, in fact, have a major impact upon the determination of the relative desirability of a particular system.

In contrast to the lower 48 states, access roads and available power are virtually non-existent for major portions of Alaska. This necessitates providing auxiliary power and a means of access. Generally, an attempt is made to locate a new navigation facility at an existing airstrip, in the vicinity of an existing airstrip or in a region where an airstrip can readily be established. Also, if the facility can be located such that established residences are in the vicinity, a large portion of the cost can be deleted (note the price of housing in Table 4.1). Similarly, the availability of local power makes a considerable difference in cost since in that case auxiliary power and additional fuel storage requirements would become unnecessary.

TABLE 4.1
ALASKA NAVAID CHARACTERISTICS[a,b,c]

SYSTEM	NDB	NDB/DME	VOR/DME	TACAN
PERFORMANCE				
COVERAGE				
RANGE (N.MI)	(10-1700)	HORIZON CUTOFF	HORIZON CUTOFF	HORIZON CUTOFF
LIMITATIONS	PROPAGATION EFFECTS (E.G., PRECIPITATION)	LINE OF SIGHT	LINE OF SIGHT	LINE OF SIGHT
SIGNAL DEPENDABILITY EFFECTED BY:	PRECIPITATION, GROUNDING	PRECIPITATION, GROUNDING	SCALLOPING MULTI-PATH	SCALLOPING EFFECTS UNKNOWN BUT LESS THAN VOR, MULTI-PATH
RELATIVE SIGNAL RELIABILITY	LOW	MED.	MED.	HIGH
REMOTE POWER REQUIREMENTS				
PRIMARY				
TYPE	DIESEL GEN	DIESEL GEN	DIESEL GEN	AUX. GEN
OUTPUT	7KW	13KW	10.5KW	1400AC - 1000DC
BACKUP				
TYPE	BATTERY	(f)	(f)	BATTERY
OUTPUT	2-4 HRS			2-4 HRS
SITING REQUIREMENTS				
ANTENNA SITE TERRAIN	GOOD GROUND CONDUCTIVITY	GOOD GROUND CONDUCTIVITY	LARGE FLAT (2000'RAD) UNOBSTRUCTED AREA	MINIMUM REQUIREMENTS
LOCAL TERRAIN	POSSIBLE PROPAGATION PROBLEMS DUE TO CANYON WALLS	LINE OF SIGHT CUTOFF	LINE OF SIGHT CUTOFF	LINE OF SIGHT CUTOFF
POWER PLANT	DIESEL	DIESEL	DIESEL	----NA----
FUEL STORAGE (NO. OF GALS.)	1 YR SUPPLY	1 YR SUPPLY	1 YR SUPPLY	1 YR SUPPLY
HOUSING	REMOTING POSSIBLE (CHANDALAR)	REMOTING POSSIBLE	REMOTING POSSIBLE (MOSES PT.)	REMOTING LIKELY
MAINTENANCE				
SCHEDULED				
FLIGHT CHECK (FREQ/YR)	25-50% OF VOR	----TBD----	----TBD----	----NA----
POWER PLANT (FREQ/YR)	ONCE/2WKS	ONCE/2WKS	ONCE/2WKS	----NA----
SNOW REMOVAL	ICE BUILDUP ON TOWERS	----TBD----	YES - CAUSES SIGNAL REFLECTION	----NA----
EMERGENCY				
REMOTE DIAGNOSTIC	EVENTUALLY	EVENTUALLY	EVENTUALLY	----NA----
ON SITE DIAGNOSTIC	----NA----	----NA----	----NA----	YES
CONTINUOUS ON SITE MANUAL	*NOT NECESSARY*	*NOT NECESSARY*	*NOT NECESSARY*	*NOT NECESSARY*
SERVICE CAPABILITY DESIRABLE	YES	YES	YES	YES
POWER SOFT FAIL MODE (HRS)	2-4 HRS	----NA----	0	4 HRS
APPROACH MINIMUMS (g)				
AVERAGE VISIBILITY (MI)	1.56	1.22	1.16	1.16
AVERAGE CEILING (FT)	1396	884	808	808
LANDING PROBABILITY	0.75	0.82	0.84	0.84
COSTS				
CAPITAL ($/UNIT)			VOR/DME	
SITE ACQUISITION & PREPARATION	97,600	129,200	365,000	118,300
ACCESS ROADS	158,600 (½ MI)	158,600	390,000 (3 MI)	158,600
POWER SOURCE	175,000	175,000	360,000	175,000
HOUSING	170,000 (IF NEEDED)	170,000 (IF NEEDED)	170,000 (IF NEEDED)	170,000 (IF NEEDED)
EQUIPMENT	20,000	20,000 (d)	----WO----(e)	150,000
INITIAL CALIBRATION, TESTS, ETC.	3,900	11,100	7,800	13,000
TOTAL	625,100	663,900 (61,000 TIE IN FOR MONITORING)	1,292,800 (EXC. OF EQUIP.) (195,000 TIE IN FOR MONITORING)	784,900 (634,900 LESS EQUIP.) (61,000 TIE IN)
RECURRING ($/UNIT/YR)				
MAINTENANCE				
LABOR				
PARTS				
FLIGHT CHECK				
TOTAL	3,830/YR	14,200/YR	27,200/YR	12,000/YR
USER IMPACT (TWIN ENG. A/C OR LARGER)				
AVIONICS COST ($/AC)	2300-4000 (ADF ONLY)	4800-9600 (ADF + DME)	5500-10,400 (NAVCOM + DME)	6750-13,200 (NAVCOM + DME + CONVERTER)

NA - NOT AVAILABLE
TBD - TO BE DETERMINED

(a) COMMUNICATION WITH BOB MORRISON OF FAA ALASKA REGIONAL OFFICE.
(b) MEMORANDUM FROM DIRECTOR, AAL-1 TO ARD-300, "INFORMATION ON NAVAID FACILITIES IN ALASKA REGION, REFERENCE ARD-331's LETTER DATED SEPTEMBER 27, 1974", NOVEMBER 6, 1974.
(c) SURVEY OF AVIONIC EQUIPMENT COSTS, A. SIMOLUNAS, J. CUPP.
(d) DOES NOT INCLUDE DME EQUIPMENT COSTS (WO).
(e) WO - WASHINGTON FURNISHED EQUIPMENT.
(f) NEW SOLID STATE VERSIONS WILL HAVE BATTERY BACKUP CAPABILITY.
(g) APPROACH MINIMUMS ARE SITE SENSITIVE, AVERAGE VALUES LISTED ARE BASED ON THE AIRPORT SET ANALYZED IN THIS STUDY FOR EACH NAVAID SYSTEM.

An additional factor affecting cost is the region where the facility is to be located. For example, a location on the North Slope presents unique construction problems due to the permafrost. In the Southeastern region, the rugged terrain and adverse weather conditions create other unique construction and maintenance (access) problems.

It is clear that the siting of navigation facilities in the State of Alaska is not nearly as straightforward as in the lower 48 states. Each proposed site typically has a unique set of problems. Hence, it becomes a challenge to identify an average cost for a particular navigation system. The system peculiar requirements for siting, access roads, auxiliary power and housing, however, provide a means to differentiate the relative ground-based navigation systems considered in this study. The basic differences in these requirements for each of the systems will be discussed in more detail in the following subsections.

4.1.1 NDB

The nondirectional beacon (NDB) is a commonly used system in the State of Alaska. This system operates at low frqeuency and is a bearing only-type navigation system. Equipment costs are relatively inexpensive since it consists primarily of a transmitter and an antenna tower. The propagation of radio waves from this system depends upon local ground conductivity. When the ground is frozen, such as on the North Slope during much of the year, the conductivity is essentially nonexistent. To overcome this problem, copper wire is placed in the ground surrounding the tower with frequent adjustments typically required.

Another problem of the NDB system is precipitation static which can essentially eliminate the propagated signal. Precipitation static is the primary disadvantage of NDB's and, in areas within the State of Alaska where large amounts of precipitation do occur, this results in extremely poor air navigation when only NDB coverage is provided. This particular propagation anomaly makes it difficult to ascertain the range of a given NDB facility. As noted in Table 4.1, the range can vary from a few miles to approximately 1500 miles to 1700 miles. Typically, the ranges are on the order of 30 to 50 miles.

Because of the lower propagation frequency associated with NDB's, the signal is not line-of-sight restricted. However, the local terrain does affect the propagated signal extensively. For example, a standing wave may be established

in a canyon and a receiver using the signal can receive erroneous information as the resulting wave bends due to the local topography. Studies* have also shown that other terrain effects exist which, in actual operation, can cause needle swings as great as 20 degrees. The amount of needle swing is also dependent, however, on the sophistication of the airborne receiver.

One additional problem that can arise, especially during the winter, is ice build-up on the towers. The effect of this build-up is a reduction in power output and, hence, range.

The above problems, when aggregated, cast considerable doubt with regard to the reliability of the present NDB navigational system.** Many of those presently implemented are modified homing devices which, in the Alaska environment, produce marginal performance characteristics. As a long-term navigation solution, it would appear to be inadequate.

The current NDB electronics are such that they are amenable to emergency battery power. Hence, in the case of power failure, the facility can be maintained for a period of 2-4 hours on battery power depending on the number of batteries available at the facility. The NDB system is scheduled to be updated with improved performance solid state electronics. This will provide the capability of remoting the sites; hence, reducing the cost. Currently, Chandalar is remoted.

4.1.2 NDB/DME

The NDB navigation system is a bearing only device and, hence, is unsuitable for a position fix. Two NDB's can be used to determine intersections and, thereby, provide a means of position determination. However, overlapping signals from at least two NDB's are required, which is a rare occurrence in the existing Alaskan system. A reasonably accurate fix can be obtained during station passage. However, it is desirable, for letdown purposes, to have information regarding distance to station. This information can be made available by colocating a DME with the NDB.

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* Berry, L.A., Fitzgerrell, R.G. and Vogler, L.E., "Investigation of Effect of Antenna Type on LF Non-Directional Beacon Performance," Report No. FAA-RD-73-174, FAA, SRDS, Washington, D.C., December 1973.

** The FAA indicated that new NDB's are expected to provide significantly improved performance.

The problem associated with combining NDB's and DME's is that a mixed propagation mode results because of the different frequencies of operation. The DME navigation system is line-of-sight dependent, whereas the NDB is not line-of-sight but has other propagation peculiarities as previously discussed. This implies that both signals may not be received simultaneously in a continuous manner. The implications of this mixed mode are not certain at this time; however, it does provide a more accurate means of letdown from enroute flight to final approach. Addition of DME to NDB does not require excessive cost as observed in Table 4.1.

Although the majority of the instrumented aircraft contain ADF avionics, not all have DME receivers (Appendix K). Hence, for NDB/DME type navigation, it becomes necessary for many users to install the additional avionics. Independent of the type of DME avionics selected, the expenditure will be significant.

4.1.3 VOR

The primary navigation system in CONUS is the VOR system. Approximately 900 ground stations are in use in the lower 48 states as opposed to 33 in the State of Alaska. It is recognized that a major reason for such a low number of VOR's is the extensive site preparation and corresponding costs typically required in Alaska. The terrain in Alaska, for the most part, does not lend itself to suitable VOR siting. In most locations, a large area must literally be levelled off in order for local terrain to be amenable to signal propagation. The extent of this preparation is reflected in the siting costs quoted for VOR in Table 4.1. The site preparation is necessary to attempt to reduce the scalloping phenomena which can occur in VOR signal propagation. The significance of siting problems associated with VOR applications in Alaska is borne out by the difficulties encountered in attempting to commission VOR facilities. For example, for the facility at Kenai, the FAA has expended a large mount of time and money during the commissioning attempts. In other areas, it is virtually impossible to site a VOR at all due to the local terrain.

During the winter months, heavy wet snow buildup on and around the counterpoise creates additional propagation problems. The snow buildup changes the characteristics of the counterpoise in such a manner that the signal accuracy degrades. The degradation can increase to such a degree that the VOR can become unusable. This is especially true in remote areas where maintenance personnel are not available to remove the snow.

Current attempts are being made to alleviate some of the VOR siting problems. These include such design changes as stacked antennas. These modifications are currently in the research and development phase and it is not certain as to their ability to overcome the typical VOR siting problems. There are, in fact, cases where more expensive DVOR's, for example, could not even be commissioned due to their inability to reduce the VOR anomalies. Further study and testing must be performed with these systems prior to drawing any conclusions regarding their usefulness for Alaska applications.

4.1.4 VOR/DME

The VOR system, which provides bearing information only, can be complimented with DME to provide sufficient information for position fixing. In CONUS, position fixing can be achieved by radial intersections from two VOR ground stations. However, as with the NDB system in Alaska, the VOR system generally has insufficient facilities to provide signals from two VOR's simultaneously. Hence, position fixing must be obtained through VOR combined with DME.

Unlike the incompatibility between NDB and DME propagation characteristics, the VOR and DME systems are compatible in that they are both line-of-sight systems. An inconsistency arises in the transmission frequencies since the VOR operates in the 100 MHz range and DME operates in the 1000 MHz range. The reason for this difference is that the DME is extracted from the TACAN portion of a VORTAC station, and TACAN operates in the 1000 MHz range (some stations have DME only). From a navigation support coverage point-of-view, the VOR and DME systems provide the same coverage which is essentially restricted by local terrain and line-of-sight limitations.

A primary advantage of combining VOR and DME is the capability to navigate in an RNAV mode. This navigation mode could be advantageous in Alaska where many uninstrumented airstrips lie in the vicinity of a VOR/DME facility. This navigation mode provides the capability to perform point-to-point navigation without the requirement of having a navigation aid at each point, although the line-of-sight factor limits the useful range (approximately 25 nm) for approach application.

4.1.5 TACAN

The NAVAID normally used by the military for bearing measurements is known as TACAN. TACAN operates in the 1000 MHz range (L-band) and, hence, requires different airborne

receiver equipment. In general, TACAN has been found to have significantly reduced scalloping effects relative to the lower frequency VOR. Some of the problems with TACAN, especially the older versions, are a 40° lock-on problem, due to the nine lobe signal pattern, and other multi-path problems.

Most of TACAN's problems have apparently been overcome, especially that of high maintenance, by the introduction of solid state electronics. Such a ground system has been developed for DOD by a number of manufacturers. This system appears to be highly reliable and accurate. One data source that provides some insight as to the feasibility of TACAN is the demonstration performed in Alaska. This demonstration consisted of placement of the system at four adverse locations: Anchorage, Kenai, Valdez and the Sparks Oil Platform. A single ground unit was used and set up at each of the four sites and flight checked within a three day period. This is particularly of interest in light of the difficulties encountered in flight checking the VOR at Kenai. However, the low antenna heights used and the minimum power radiated, to minimize multipath problems, may limit TACAN's practicality even if accepted as a substitute for VOR.

Another data source is the unit installed by Aspen Airways in Aspen, Colorado. Many unsuccessful attempts had been made to provide navigation support in this area. The TACAN system has seen successful operation since its commissioning over a year ago.

Because of the type of electronics associated with the new solid state TACAN unit, the power requirements are not great. The units can be operated using auxiliary battery power. Because of the low power requirements, the transportation and storage of fuel (one year supply) requirements are not as extensive as for the other navigation systems.* Perhaps even more important, the nature of the signal propagation does not require as extensive site preparation as NDB (grounding) and VOR (leveling local terrain) systems.

The portability of the unit is also an attractive feature. The claim has been made that the unit, with an FAA-approved shelter, can and has been slung from a helicopter. However, it was indicated that remote sites may still require housing and access roads; thereby adding to the individual costs and thus minimizing TACAN's potential advantage.

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*The FAA indicated that this advantage is expected to be reduced or eliminated when the new generation VOR/DME system becomes operational.

The TACAN system must also be evaluated on a site-by-site basis with regard to cost. For example, if the system is not completely portable and cannot be totally remoted (access road and housing required), the cost, as seen from Table 4.1, is $695,900, exclusive of equipment. If the facility can be located on an existing building or in such a manner that new housing, power and access roads or airfields are not required, the cost, over and above equipment is $24,000 for a shelter* and flight inspection. The VOR, on the other hand, costs $1,487,000 for the completely remoted site exclusive of equipment. This is approximately twice the cost for a comparable TACAN facility. What the requirements for the minimum VOR facility are is uncertain at this time. However, if that minimum is assumed to consist of preparation, building and flight inspection, then the associated cost is estimated to be $372,800, which is substantially greater than the corresponding TACAN cost. Assuming that VOR/DME equipment costs are on the order of $300,000**, the price differential is on the order of four to one for the minimum ssystems. The impact of cost on a site-by-site basis should be determined which, however, would require a detailed analysis that is beyond the scope of this study.

A significant disadvantage of the TACAN system is that it requires avionics of a different nature than what is currently utilized. However, a bearing unit adapter may be forthcoming which can be made compatible with most existing DME receivers. The cost of this adapter has been estimated to be 50% of the cost of the DME being upgraded. Hence, a DME costing $2,000 could be upgraded to a complete airborne TACAN unit for an additional $1,000 or a $10,000 DME could be upgraded for an additional $5,000. The problem is that many users would have to completely re-equip to use this system, since few have DME at present.

One additional consideration is that implementation of a TACAN system as a navigation gap filler does not require a completely new set of ground facilities. On the contrary, an examination of Alaskan facilities reveals 28 VORTAC's, 2 VOR/DME's, and 3 VOR's. The VORTAC's are civilian VOR's co-located with TACAN. Hence, TACAN navigation is currently available from 28 of 33 facilities. Implementing additional TACAN's

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*$11,000 of site acquisition and preparation cost apportioned to equipment shelter.

**New VORTAC equipment is currently estimated by the FAA to cost considerably less but the siting and other logistic costs should still override this factor.

as gap fillers would be compatible with the already existing dual VOR/TACAN system. Conversely, TACAN is not internationally accepted and it is questionable whether this condition will ever change. Hence, TACAN, if implemented for Alaska's civil users, would be a unique solution for a specialized user group. This is an especially important factor since Loran-C, Omega, and/or GPS/NAVSTAR are the prime contenders for VOR replacement.

4.2 ALASKAN AIRBORNE AVIONICS

The determination of the potential benefits of any proposed navigation system, particularly for short-term and/or interim implementation, must be based upon the ability of the users to utilize the systems. In this regard, the avionics systems currently in use in Alaska are of considerable importance.

FAA Aircraft Master Registration Tapes contain a variety of data items pertaining to each aircraft currently registered with the FAA. While the data were based upon 1974 registrations, it was considered sufficiently current to provide usable avionics statistics. Detailed information obtained from these tapes is presented in Appendix K.

An examination of Table K.1 of Appendix K reveals that only 30 of 341 air taxi aircraft are equipped with the avionics to operate both in a NDB/DME mode and a VOR/DME mode. Including the RNAV equipped aircraft, only 52 or 15% of the total air taxi aircraft have DME's. This would imply that the majority of air taxi operators would have to invest in DME equipment to take full advantage of the proposed interim solution of NDB/DME. On a total Alaska fleet basis the percentage is even less, only 301 had ADF/VOR/DME (including those with RNAV) avionics, or 8.4% of the total.

V. EVALUATION OF SHORT-TERM ALTERNATIVES

An objective of this study was to establish a recommended implementation sequence or ranking of candidate navigation aid locations, based on the anticipated benefit that would result from their incorporation into Alaska's Air Navigation System.

As indicated in Section III, improvements are needed for both enroute and approach applications. The enroute needs may be characterized as "gap filling" of existing routes as well as the creation of new routes. The approach applications include providing new instrument approaches and/or lowering the minimums at airfields that currently have instrument approach capabilities.

Due primarily to the lack of detailed records, sufficient quantified information was not available from Alaska's air navigation system user groups to permit the determination of the costs incurred by the users attributable to either the total or individual navigation system deficiencies.

If these costs could have been estimated, it would have been possible to establish a single figure of merit, i.e., reduced user costs, for each candidate NAVAID installation, independent of whether its primary application was enroute, approach or both.

In lieu of a single figure of merit, separate, performance related criteria were established for both enroute and approach applications. Application of these two sets of criteria produced results which were subsequently used in conjunction with a third, somewhat more subjective, set of criteria developed to establish a recommended implementation sequence for the combined set of proposed enroute, approach, and dual (enroute and approach) NAVAID locations.

Each of these three sets of criteria were applied to the five types of NAVAIDS (NDB, NDB/DME, VOR, VOR/DME and TACAN) considered to be feasible for short-term solutions of Alaska's air navigation problems. This was accomplished by first identifying a baseline implementation sequence predicated on such factors as the ranking and supporting rationale supplied by each user group for their recommended installations, impressions gained through personal exposure to the problem areas and operating procedures, the dependence of a community on reliable air transportation, and the need of a region for IFR routes.

The resulting baseline priority established for each proposed NAVAID improvement was then adjusted to account for the capability of a specific type of NAVAID to provide the type of improvement requested. If all NAVAIDS provided the desired performance, then the recommended implementation sequence would be identical to the aforementioned baseline priority ranking. However, if one or more of the candidate NAVAIDS did not provide what was considered to be an adequate improvement for a given user request; then those request-NAVAID combinations were lowered within, or eliminated from, the implementation sequence associated with that type of NAVAID. This procedure resulted in 15 recommended implementation sequences, or rankings, one for each combination of the five NAVAID types, and three primary applications.

This "multiple solution" approach was taken to provide the decision maker flexibility in selecting the type of NAVAID most appropriate for the short-term upgrading of Alaska's air navigation system. With this approach, factors external to this analysis, i.e., hardware availability, compatibility with "long-term" navigation systems, etc., may be used to select the most appropriate NAVAID type. An overview of the elements and interactions which make up this approach is depicted in Figure 5.1.

Section 5.1 presents the implementation ranking and supporting rationale for those sites recommended to enhance the enroute navigation system. Similar material is presented in Section 5.2 for those sites recommended for improved approach aids. Finally, an implementation sequence covering all candidate locations recommended for either enroute, approach, or dual applications is developed and presented in Section 5.3.

5.1 ENROUTE AID EVALUATION

The procedure used to rank the enroute navigation aids considered not only the "gap filling" potential of a proposed NAVAID, but also took into account estimates of the traffic which would be served by that aid. Hence, two distinct tasks were involved which, when merged, produced the desired results. The first task addressed the identification of existing enroute navigation gaps (or lack of an entire route segment) in the proximity of recommended enroute aids. Subsequent analysis of each gap, using ECAC data when available and the coverage characteristics of each candidate navigation system, produced, for each system, the expected improvement in navigation coverage.

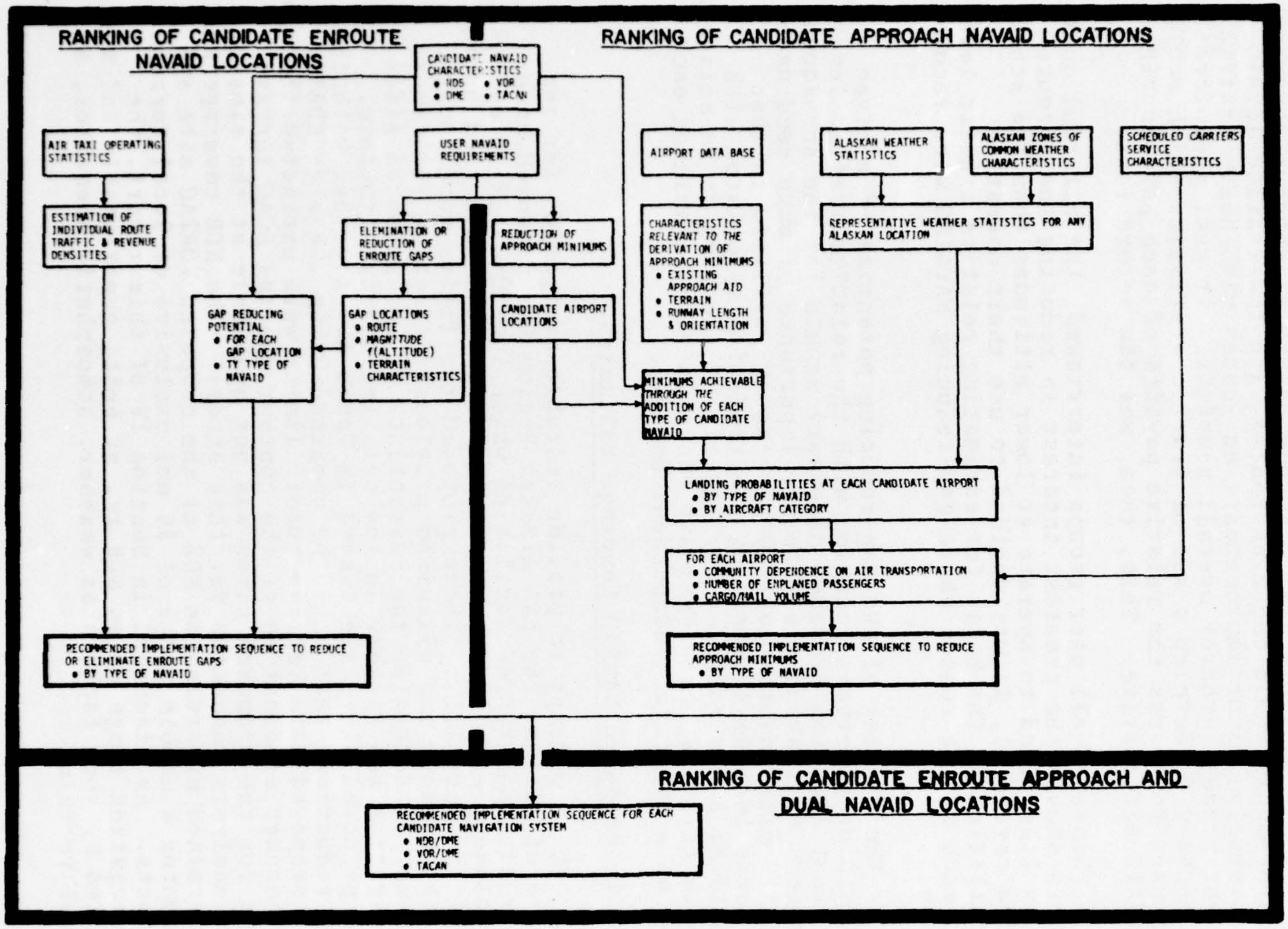


Figure 5.1 Approach for the Ranking of Candidate NAVAID Locations

It is possible that, in some cases, tremendous coverage improvements would occur on routes with low traffic levels; conversely, minor improvements on routes with heavy traffic might produce greater overall benefits. It was, therefore, necessary to develop a set of traffic statistics which could be used to assess the relative payoffs of each gap-reducing NAVAID alternative. This, then, was the second task.

Since of all user groups interviewed, the air taxi operators showed the greatest interest in reducing the enroute gaps (they tend to operate at lower altitudes than the scheduled carriers), it was decided to use their operating statistics as the basis for estimating relative traffic levels on each of the routes where gap-reducing NAVAIDS were recommended.

The merging of the gap-reducing potential of a given NAVAID at a certain location with the relative traffic levels at that location provided necessary inputs for the subsequent process of ranking the relative importance of each candidate NAVAID-site combination. Other factors utilized in that process include determining the tradeoffs associated with building a new route or filling all of the gaps on an existing route (i.e., a route-by-route analysis verus examining each gap as a separate, independent entity).

5.1.1 Proposed NAVAID Coverage Estimates

In an attempt to provide suitable navigation for the State of Alaska, the FAA Alaskan Region has proposed some 28 additional VORTAC facilities which included six locations in close proximity to or the same as those recommended by the AACA (Section III). These proposed facilities were located on the contour map discussed previously (Section III) in an attempt to determine the suitability of the proposed sites as navigation gap fillers in the existing airway structure. The proposed sites are listed in Table 5.1 together with the gap reductions that could be obtained using VOR's or NDB's. The proposed site terrain cutoff limits were extracted through a thorough examination of the contour map (as ECAC terrain data for the proposed sites was not available at the time of the analysis conducted for this study). The NDB coverage was determined by siting an NDB at the proposed VORTAC site and assuming a usable range of 50 nmi exclusive of local terrain effects. As discussed in Section IV of this report, the propagation range of an NDB is, at best, questionable and may varied by such factors as weather, atmospheric anomalies, and local terrain.

Table 5.1
VOR and NDB Enroute Navigation Gap Reducing Potential

PROPOSED FACILITY	DESTINATION FACILITY	VICTOR ROUTE	VOR GAP REDUCTION						NDB GAP REDUCTION(2)						REDUCED MEA (1)
			3,000' ASL		8,000' MSL		13,000' MSL		3,000' ASL		8,000' MSL		13,000' MSL		
			FROM	TO	FROM	TO	FROM	TO	FROM	TO	FROM	TO	FROM	TO	
St. Mary's*	OME-BET	V506	95	10	10	0	---	---	95	34	10	0	---	---	Yes
Sparrevohn*	ANC-BET	NEW (G-9)	197	90	138	0	77	0	197	109	138	51	77	5	(3)
St. Paul	Cape Newenham	NEW (4)	---	---	---	---	---	---	(5)	---	---	---	---	---	---
Haines	SSR-DB	A-15 (6)	---	---	---	---	---	---	---	---	---	---	---	---	---
Barter Isl.	SCC	NEW	---	---	---	---	---	---	---	---	---	---	---	---	---
	Arctic Village	NEW	---	65	---	---	---	---	---	27	---	---	---	---	5,000
Chandalar	SCC-ENN	V436	210	116	132	0	64	0	210	113	132	31	64	0	5,000
	SCC-FAI	V347	180	82	120	0	70	0	180	80	120	19	70	0	6,000
Cape New.	St. Paul-DLG	NEW	---	---	---	---	---	---	(5)	---	---	---	---	---	---
Cape Spencer	YAK-BKA	V440	60	0	---	---	---	---	60	---	---	---	---	---	Yes
	YAK-SSR	V317	28	0	---	---	---	---	28	0	---	---	---	---	Yes
Cape Yakataga	JOH-YAK	V317	105	14	23	0	---	---	105	40	23	0	---	---	---
Cordova	GKN	NEW	---	---	---	---	---	---	---	---	---	---	---	---	8,100
	JOH-YAK	V317	105	0(7)	23	0(7)	---	---	105	4(7)	23	0(7)	---	---	---
Iliamna	ANC-AKN	V427	120	64	36	0	---	---	120	39	36	9	---	---	10,200
	AKN-ENA	V456	80	10	16	0	---	---	80	6	16	0	---	---	3,500
Puntilla Lake	BGQ-MCG	V510	58	20	8	0	---	---	58	0	8	0	---	---	5,500
	ANC-MCG	V440	93	20	24	0	---	---	93	0	24	0	---	---	6,500
Sagwon	CHAND-SCC	V436	73	20(8)	---	---	---	---	73	15(8)	---	---	---	---	6,500
Wien Arctic V.	FYU-BTI	NEW	---	---	---	---	---	---	---	---	---	---	---	---	---
Bornite*	(9)	5 NEW	---	---	---	---	---	---	---	---	---	---	---	---	---
Umiat*	(10)	5 NEW	---	---	---	---	---	---	---	---	---	---	---	---	---
Wainwright	(11)	3 NEW	---	---	---	---	---	---	---	---	---	---	---	---	---
Aniak	BET-MCG	V480	120	45	50	0	---	---	120	67	50	40	---	---	2,200
Summit	BCQ-FAI	V438	105	60	38	0	---	---	105	24	38	0	---	---	6,000
	ENN-TKA	V436	0	0	---	---	---	---	0	0	---	---	---	---	---
Minchumina	ENN-MCG	V480	97	0	35	0	---	---	97	30	35	0	---	---	---
Lonely	(12)	NEW	---	---	---	---	---	---	---	---	---	---	---	---	---
Stevens Vill.*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Cape Lisburne	OTZ	NEW	---	---	---	---	---	---	---	---	---	---	---	---	---
Adak	Aleutians	NEW	---	---	---	---	---	---	---	---	---	---	---	---	---
Amchitka	Aleutians	NEW	---	---	---	---	---	---	---	---	---	---	---	---	---
Nikolski	Aleutians	NEW	---	---	---	---	---	---	---	---	---	---	---	---	---
Pt. Heiden*	AKN-CDB	V456	145	30	78	0	15	0	145	70	78	28	15	0	---
Cape Sarichef	Aleutians	NEW	---	---	---	---	---	---	---	---	---	---	---	---	---

(1) A number in this column corresponds to the highest terrain elevation encountered on the route segment; (2) NDB's assumed to have 50 nmi range limitation; (3) MEA over Alaska range 12,500 ft cannot be reduced because of mountains; however, west of this range the highest terrain elevation is 3,800 ft; all of the navigation gaps appear west of the Alaska range; (4) NEW implies a proposed Victor route by the Alaska Regional Office; (5) NDB's cannot be used since the proposed Victor route is over water; (6) DB is Burwash in the Yukon ; (7) with Cape Yakataga; (8) with Chandalar; (9) five proposed Victor routes from Bornite to Kotzebue, Umiat, Bettles, Tanana and Galena; (10) five proposed Victor routes from Umiat to Wainwright, Pt. Barrow, Pt. Lonely, Chandalar and Bornite; (11) three proposed Victor routes from Wainwright to Cape Lisburne, Pt. Barrow and Umiat; (12) three proposed Victor routes from Lonely to Pt. Barrow, Deadhorse and Umiat.

*Also recommended for VOR/DME's by the Alaska Air Carriers Association representing the air taxi operators (Bornite replaces Kobuk from the AACA list).

Also noted in Table 5.1 is a column headed, "REDUCED MEA." If the MEA is the result of navigation limitations, then the reduced MEA due to added navigation capability is denoted by "YES." If a terrain limitation persists, then the highest terrain elevation in the controlled airspace associated with a particular airway is noted.

5.1.2 Estimated Distribution of Low Altitude Traffic

The evaluation procedure developed to determine the relative importance of providing coverage for specific enroute gaps or new routes considers the level of traffic exposed to that gap. The best available source of traffic data, for this application, appeared to be air taxi statistics. While partial scheduled carrier data was also obtained, a large proportion of that traffic was estimated to be high altitude, where coverage gaps are minimal so as not to be of major concern.

Access to basic, hand posted, air taxi operations and revenue data was provided by the Alaska Transportation Commission. A considerable amount of computer processing was necessary to transform this basic data into a usable format displaying air taxi annual traffic and revenue totals by operator base community. Copies of the computer outputs were provided to the AACA who estimated the distribution of these base community totals to other Alaska regions. Subsequent analysis of these data produced estimates of the desired origin-destination statistics which were then aggregated to provide traffic and revenue levels for each of the routes of interest. These results, in the form of a relative ranking by origin-destination region and effected routes are summarized in Table 5.2, which is based on low altitude IFR traffic. A detailed description of this analysis is presented in Appendix E.

5.1.3 Ranking of Candidate Enroute Aids

Using the data described in Sections 5.1.1 and 5.1.2, a baseline ranking (i.e., independent of the type of NAVAID used) was developed considering the traffic weighted improvement potential of each candidate site. For those regions where airways have been proposed, but do not currently exist (hence, no navigation gap data), a judgment was made concerning the need of an aid based again on air traffic. A preference was given to regions where no navigation support existed (for example, the Aleutians), when compared to regions where MEA's are prevalent because of unsuitable navigation support.

Table 5.2

Traffic Flow Ranking

RANK	BY ANNUAL NO. OF FLIGHTS		BY ANNUAL REVENUE	
	REGION	VICTOR ROUTE	REGION	VICTOR ROUTE
1	ANC-N	V436,438	ANC-N	V436,438
2	ANC-W	G-9*	ANC-W	G-9*
3	FAI-N	V347	FAI-N	V347
4	ANC-SW (CHAIN)	V456,438,427	ANC-SW (CHAIN)	V456,438,427
5	FAI-W	V452,488	FAI-W	V452,488
6	ANC-SE	V317,440	ANC-SE	V317,440
7	FAI-SW	V480	FAI-SW	V480
8	BET-N	V506	KTZ-OME-N	V506
9	KTZ-OME-N	V506	KTZ-OME-E	V452,498
10	KTZ-OME-E	V452,498	BET-N	V506
11	FAI-SE	V444	FAI-SE	V444
12	BET-SE	V506,453	BET-SE	V506,453
13	BET-NE	V480	BET-NE	V480

*Non-Victor Route Green-9

ANC	- Anchorage	E	- East
BET	- Bethel	N	- North
FAI	- Fiarbanks	NE	- North East
KTZ	- Kotzebue	SE	- South East
OME	- Nome	SW	- South West
		W	- West

For the enroute analysis, no consideration was given to a particular facility's application as an approach aid.

Table 5.3 presents the resulting rankings of recommended new enroute NAVAID locations for NDB, NDB/DME, VOR, VOR/DME, and TACAN systems, respectively. For the NDB system, those proposed sites with an existing FAA-owned and operated facility were deleted from the ranking (sites with DOD and private aids were retained). In adding DME to the NDB, a judgment was made

Table 5.3

Recommended Implementation Sequence of Candidate Enroute Facility Locations by NAVAID Type

BASELINE RANKING OF PROPOSED ENROUTE FACILITY LOCATION	NDB	NDB/DME	VOR	VOR/DME	TACAN
1. Chandalar	(a)	1	1(b)	1(b)	1
2. Sparrevohn	1	2	2	2	2
3. Yakataga	(a)	3	3(b)	3(b)	3
4. Port Heiden	(a)	4	4	4	4
5. Iliamna	(a)	5	5(b)	5(b)	5
6. St. Mary's	2	6	6	6	6
7. St. Paul Island	3	8	7	7	7
8. Cape Newenham	4	9	8	8	8
9. Cape Sarichef	5	10	9	9	9
10. Umiat	(a)	7	10	10	10
11. Nikolski	6	14	11(b)	11(b)	11
12. Adak	7	15	12(b)	12(b)	12(c)
13. Bornite	8	16	13	13	13
14. Aniak	(a)	11	14	14	14
15. Rainy Pass Lodge	(a)	12	15(b)	15(b)	15
16. Minchumina	(a)	13	16	16	16
17. Cape Spencer	9	19	17(b)	17(b)	17
18. Haines	(a)	17	18(b)	18(b)	18
19. Summit	(a)	18	19(b)	19(b)	19
20. Barter Island	10	20	20	20	20
21. Lonely	11	23	21	21	21
22. Wainwright	12	24	22	22	22
23. Cape Lisburne	13	25	23	23	23
24. Amchitka	14	26	24	24	24
25. Wien Arctic Village	15	21	25(b)	25(b)	25
26. Sagwon	16	27	26	26	26
27. Cordova	(a)	22	27(b)	27(b)	27
28. Stevens Village	17	28	28(b)	28(b)	28

(a) Has FAA owned and operated NDB's; (b) VOR siting could be a problem due to local terrain; (c) Has military TACAN

regarding the availability of an FAA-owned NDB. In some locations, the existence of an FAA NDB improved the ranking. (Note: the rankings of Aniak, Rainy Pass Lodge and Minchumina interchanged with St. Paul Island and Cape Newenham.)

The VOR, VOR/DME and TACAN ranking generally parallel the overall ranking since it is assumed that none of these facilities exist at the proposed sites (although Adak does have a military TACAN). Where VOR siting is a potential problem, a note is made.

The following discussion presents the rationale used in ranking each of the twenty-eight proposed enroute navigation facilities on an overall basis, and then for each of the five types of navigation aids. The facilities are listed according to their overall ranking.

5.1.3.1 Chandalar

Chandalar was ranked Number 1 on an overall basis for the following reasons. On V436, between Nenana and Deadhorse at 3,000 ft above the site, a 210 nautical mile gap exists; at 8,000 ft MSL, a 132 nautical mile gap exists; and at 13,000 ft MSL, a 64 nautical mile gap exists. Similarly, on V347, between Fairbanks and Deadhorse at 3,000 ft ASL, a 180 nautical mile gap exists. At 8,000 ft MSL, a 122 mile gap exists and at 13,000 ft MSL, a 70 nautical mile gap exists. (The gap data is presented in Table 5.1.) From Table 5.2 it can be seen that this location would serve all of the third and a portion of the first ranked routes with respect to the number of low altitude IFR flights and associated revenue. The highest terrain elevation in this area is approximately 6,000 ft MSL. This data indicates that gaps on the order of 130 nautical miles exist on the airways carrying a large portion of the Alaska air traffic. Chandalar is currently a focal point for all traffic to the North Slope from the Fairbanks, Anchorage, and lower 48 regions. For this reason, Chandalar was ranked as that enroute facility requiring top priority.

Currently, Chandalar has an FAA owned and operated NDB. Hence, Chandalar does not appear in the NDB ranking. However, for NDB/DME the Chandalar NDB would require the addition of a DME. Hence, it remains first in this category. The local terrain about Chandalar is very rugged and does not make it amenable to VOR siting. Use of TACAN should ease the siting problem, but would require considerable user expense.

5.1.3.2 Sparrevohn

Sparrevohn lies between Anchorate and Bethel where a large navigation gap exists. The only facilities providing coverage between Anchorage and Bethel are the VORTAC at Anchorage and the VORTAC at Bethel. Currently, the only route between Anchorage and Bethel is Route G-9. The resultant navigation gap is 197 nautical miles at 3,000 ft above the site, 138 nautical miles at 8,000 ft MSL, and 77 nautical miles at 13,000 ft MSL. The estimated traffic flow (Table 5.2) is ranked second, trailing only the traffic heading north toward the North Slope. Hence, because of the lower traffic density along this route, Sparrevohn is ranked second to Chandalar.

Sparrevohn currently has a DOD-owned and operated NDB. However, non-FAA NDB's were not considered as viable public navigation aids in this analysis. Hence, the assumption is made that the FAA would either have to acquire the DOD NDB or install their own at this point. Therefore, Sparrevohn is ranked as Number 1 for NDB NAVAID installations. With regard to NDB/DME, Sparrevohn is again ranked as Number 2, the same as the overall ranking. The VOR siting problem is not as great at Sparrevohn as it is at Chandalar. Under TACAN, Sparrevohn is ranked second.

5.1.3.3 Yakataga

Yakataga is on the coast of the Gulf of Alaska between Johnstone Island and Yakutat. The routes associated with these facilities carry the IFR traffic from the central Alaska region to the southeastern region and to the lower 48. Based on data supplied by the Alaska Air Carriers Association, the traffic density along this route is ranked sixth. Currently, a gap of 105 nautical miles exists at 3,000 ft above the site, and 23 nautical miles at 8,000 ft MSL. The fact that this route provides the primary link between Alaska and the lower 48 justifies this site to be ranked third. The scheduled air carriers also experience a navigation gap in this region at altitude; however, it apparently does not create a serious problem, as the gap is not that extensive and the degree of dead reckoning required does not appear to be unreasonable.

Yakataga does have an NDB so this facility was not included in the NDB ranking column. Under the NDB/DME and TACAN ranking, Yakataga remains in third place. VOR siting could be a problem for Yakataga since it is located on the coast in an area of rugged terrain.

5.1.3.4 Port Heiden

Port Heiden is in a key location for traffic from the Anchorage Region to the Aleutians. Currently, a VOR exists at King Salmon and at Cold Bay, a distance of approximately 280 nautical miles. Port Heiden lies almost in the center of the airway connecting King Salmon and Cold Bay. A Port Heiden facility would also provide coverage for traffic between Kodiak and Cold Bay. The existing gaps currently are 145 nautical miles on the Victor airway between King Salmon and Cold Bay at 3,000 ft, 78 nautical miles at 8,000 ft MSL, and 15 nautical miles at 13,000 ft MSL. In Table 5.2, the traffic density is ranked fourth. A combination of the traffic density and the gap size provided the rationale for this ranking.

Port Heiden has an NDB; therefore, it does not appear in the NDB ranking. The NDB/DME and TACAN rankings remain at four for Port Heiden. Port Heiden does not appear to have the VOR siting problems that probably exist at Yakataga, as a result it is moved up from fourth to third.

5.1.3.5 Iliamna

Iliamna is also in a key location for air traffic to the Aleutians. However, the gaps on the existing airway structure are not as great as at Port Heiden. The gaps on V456 between Kenai and King Salmon are 80 nautical miles at 3,000 ft above the site and 60 nautical miles at 8,000 ft MSL and no gap at 13,000 ft MSL. Along V427 between Anchorage and King Salmon, the gaps are 120 nautical miles at 3,000 ft above the site and 36 nautical miles at 8,000 ft MSL. The highest terrain elevation for V456 and V427 is 3,500 ft and 10,200 ft, respectively.

Iliamna also has an NDB. The TACAN and NDB/DME rankings remain at five for Iliamna. However, Iliamna lies in mountainous terrain where VOR siting might be a problem; expecially to the north. For this reason, Iliamna, in the VOR and VOR/DME ranking columns, was dropped from fifth to sixth.

5.1.3.6 St. Mary's

St. Mary's lies along V506 between Bethel and Nome. The traffic density along this route was ranked eighth, as shown in Table 5.2. Currently, the navigation gaps are as follows: 95 nautical miles at 3,000 ft above the site, and 10 nautical miles at 8,000 ft MSL.

St. Mary's does not have a FAA owned and operated NDB. Since St. Mary's is only the second of the first six sites not to have an NDB, it ranks second in the NDB column. With regard to NDB/DME and TACAN, St. Mary's remains in sixth place. St. Mary's lies in the flat land surrounding the Bethel Region. Hence, VOR siting does not appear to be a problem.

5.1.3.7 St. Paul Island

St. Paul Island is situated approximately 600 miles west off the coast of Alaska in the Bering Sea. No statistics of traffic to this island are available. However, any flight which is aborted due to weather at the island requires a 600 mile return flight to the mainland. Hence, it is highly desirable to have navigation available to reduce the number of aborted flights because of the associated high cost with an alternate airport.

St. Paul does not have a FAA operated NDB, so it is ranked third in the NDB column; since it would be necessary to include both NDB and DME costs, the NDB/DME ranking for St. Paul was dropped to eighth from seventh. For the VOR and VOR/DME and TACAN systems, the ranking remains at seven.

5.1.3.8 Cape Newenham

Cape Newenham is required to complete the navigation coverage for flights from Dillingham to St. Paul Island. Cape Newenham and St. Paul Island are complementary. For this reason, Cape Newenham is ranked eighth, just after St. Paul.

The ranking for each of the five NAVAIDS was set at one greater than the ranking established at St. Paul for the same type of NAVAID.

5.1.3.9 Cape Sarichef

Cape Sarichef is the next proposed site along the Aleutian Chain after Cold Bay. It would be desirable to have a plot of the air traffic density along the Aleutian Chain to see how it tapers off as a function of distance along the Chain. In the absence of this data, the assumption was made that the further one progresses west along the Aleutian Islands, the less dense the air traffic becomes; therefore, the less important the proposed site. Hence, traffic to Cape Sarichef and beyond is assumed to be at a lower level than traffic to Cold Bay and beyond, which accounts for Cape Sarichef's lower ranking.

The ranking in each of the NAVAID columns follows sequentially that of Cape Newenham.

5.1.3.10 Umiat

Umiat is on the North Slope and is located such that it would provide the navigation support for a new route from southern Alaska to Lonely, Point Barrow, and Wainwright. Since the route structure that Umiat would support is proposed, no gap information or traffic statistics exist. However, the proposed configuration of the new route structure is such that Umiat appears to be in the key location.

Umiat currently has an NDB and, hence, does not appear in the NDB ranking. Similarly, the ranking for NDB/DME moves to seventh place because only a DME is required to upgrade it to a NDB/DME system. The ranking for the VOR, VOR/DME and TACAN system is tenth.

5.1.3.11 Nikolski

Nikolski is the next proposed location on the Aleutian Island Chain. For the reasons stated for Cape Sarichef, Nikolski's ranking was reduced under the assumption that the traffic density drops in progressing out along the Chain.

The NDB ranking follows the preceding ranking, and hence, Nikolski is ranked sixth. With regard to NDB/DME, the ranking of Nikolski slips to fourteenth place since other proposed sites (for example, Aniak, Rainy Pass Lodge and Minchumina) have NDB's. Nikolski would require the addition of both NDB and DME. The terrain surrounding Nikolski is quite rugged and, therefore, it is not amenable to VOR siting. The TACAN ranking is eleven.

5.1.3.12 Adak

Adak follows Nikolski on the Aleutian Chain. It has the same problems that Nikolski does in that the terrain is rugged and that it does not have an NDB. Hence, its ranking for NDB, NDB/DME, and VOR/DME follows that of Nikolski. Adak did, at the time of this study, have a TACAN facility.

5.1.3.13 Bornite

Bornite is located south of the Brooks Range between Kotzebue and Bettles Field. Bornite would support a large route structure in the northwestern region of Alaska. The traffic flow in this region is ranked tenth. Its potential contribution to the proposed route structure provided the rationale to rank Bornite in thirteenth place.

Bornite does not have an NDB; hence, it is ranked eighth in the NDB column and sixteenth in the NDB/DME column. The siting should not be as difficult at Bornite as at Nikolski and Adak for the VOR system. For the VOR, VOR/DME and TACAN, it is ranked twelfth after Nikolski.

5.3.1.14 Aniak

Anika would support traffic along V480 between Bethel and McGrath. The traffic flow along this route is ranked thirteenth. Currently, a navigation gap of 120 nautical miles exists at 3,000 ft above the site and 50 nautical miles at 8,000 ft MSL. The highest terrain along this airway is 2,200 ft.

Aniak has an NDB and hence does not appear in the NDB ranking. Since it has an NDB, only a DME need be added to bring it to NDB/DME status. Therefore, its ranking for this system is eleventh. The ranking for the VOR, VOR/DME and TACAN is fourteenth.

5.1.3.15 Rainy Pass Lodge

Rainy Pass Lodge is located near Puntilla Lake. This proposed facility would support traffic along V510 and V440. Traffic statistics do not exist for these routes; however, these routes do carry the traffic from Anchorage to McGrath and on to Nome. It would appear that this is a reasonably dense traffic area. The gaps existing along this route are not extensive. At 3,000 ft above the site it is 93 nautical miles and at 8,000 ft it is 24 nautical miles for V440. For V510, it is 58 nautical miles at 3,000 ft above the site and 8 nautical miles at 8,000 ft MSL. Traffic would probably be at 8,000 ft and above since the highest terrain in this area is 6,500 ft.

Currently, Rainy Pass Lodge has an NDB. Hence, its ranking does not appear in the NDB column. Since there is an NDB at Rainy Pass Lodge, it is only necessary to add a DME to bring it to NDB/DME status. For this reason, Rainy Pass Lodge ranks twelfth for the NDB/DME system. The terrain in the Rainy Pass Lodge region is quite rugged. Hence, VOR siting would probably be a problem. With regard to TACAN, the ranking follows that of Aniak and is fourteenth.

5.1.3.16 Minchumina

Minchumina supports traffic between Fairbanks and McGrath and ranks seventh according to the Alaska Air Carriers Association. The gaps along V480 between Nenana and McGrath are 97 nautical miles at 3,000 ft above the site and 35 nautical miles at 8,000 ft. The lower air traffic density along this route resulted in ranking Minchumina sixteenth.

Minchumina does have an FAA owned and operated NDB. Hence, it is not ranked in the NDB system column. The terrain in the vicinity of Minchumina is not as rugged as in Rainy Pass Lodge. The ranking for the TACAN system places Minchumina below Rainy Pass Lodge at fifteen.

5.1.3.17 Cape Spencer

Cape Spencer is located in the southeastern region and is at the entrance of the Pacific Ocean to the inlet structure to Juneau. The terrain is quite rugged and navigation gaps do, in fact, exist. On V440 from Yakatat to Biorka Is., a gap of 60 nautical miles at 3,000 ft above the site exists and along V317 between Yakatat and Sisters Is., a gap of 28 nautical miles at 3,000 ft above the site exists. No traffic statistics exist for these routes. However, these routes do support the traffic from the central region of Alaska to Juneau and to the lower 48 states.

Cape Spencer does not have an NDB. Hence, it is ranked ninth in the NDB system category. It ranks nineteenth for NDB/DME since both a NDB and a DME would be needed. As noted, the terrain is very rugged in the southeastern region. Hence, VOR siting is a significant problem. The siting difficulty affects the VOR, VOR/DME and TACAN systems.

5.1.3.18 Haines

Haines is located at the northern end of the southeastern panhandle and lies in the same type of terrain as Cape Spencer. Haines is located even further up the channel, hence making siting quite difficult. Not current route structures exist except for colored routes penetrating into Canadian airspace. Therefore, no navigation gap data exist.

Haines does have an NDB and therefore does not appear in the NDB ranking. The ranking for the other navigation systems is just below that established for Cape Spencer.

5.1.3.19 Summit

Summit is located in the dense traffic area between Anchorage and Fairbanks. This traffic area has, in fact, been ranked number one, based on data supplied by Alaska Air Carriers Association as well as Wien Air Alaska statistics. Currently, a navigation gap of 105 nautical miles does exist at 3,000 ft above the site; and at 8,000 ft MSL the gap is 38 nautical miles. However, the highest terrain along this airway is at 6,000 ft. Hence, traffic would again be at 7,000 ft

or above. In spite of the large traffic experienced in this portion of the Alaska airway system, a ranking greater than 19 does not appear to be justified because an alternate route exists via Big Lake, Talkeetna, Tenana and Fairbanks. Alternate route structures do not exist for the other candidate locations examined.

Summit has an NDB; hence, it was not included in the NDB ranking. Summit is in a rugged terrain where VOR siting could become a problem. The terrain does not appear to be too rugged to preclude siting a TACAN. The TACAN ranking was set at sixteenth.

5.1.3.20 Barter Island, Lonely, Wainwright and Cape Lisbourne

Bater Island is on the northeastern portion of Alaska on the Arctic Ocean Coast. The rationale behind the low ranking of Barter Island and other North Slope facilities is that the North Slope traffic situation is assumed to be short-term, dependent on the continuation of pipeline and oil exploration activities. Further, there is a reasonable probability that the temporary air navigation requirements will be supplied by the involved organizations. This is not true, of course, for the Chandalar and Umiat facilities, which would probably carry the brunt of the air taxi operator traffic to the North Slope. The ranking between the North Slope facilities remaining is of minor significance. None of the North Slope facilities have existing FAA-owned and operated NDB's. Hence, the ranking simply follows the baseline ranking. The only North Slope facility which has a VOR siting problem is Wien Arctic Village, which lies between Fort Yukon and Barter Island. Wien Arctic Village and Sagwon are connecting facilities from the southern Victor route structure to the coast of the Arctic Ocean. Lonely, Wainwright, and Cape Lisbourne are along the coastline of the Arctic Ocean and form a Victor airway network along the coastline and are nominally ranked 21, 22, and 23, respectively.

5.1.3.21 Amchitka

Amchitka is the next proposed location on the Aleutian Island Chain. The comments made for Adak (ranked Number 12) are true for Amchitka except that it does not contain a TACAN.

5.1.3.22 Wien Arctic Village, Sagwon, and Cordova

Wien Arctic Village and Sagwon are ranked 25 and 26, respectively. Cordova is located between Yakataga and Johnstone Island. However, if Yakataga is implemented then Cordova does not add much to the filling of navigation gaps existing along the routes from Anchorage to the southeastern panhandle. For this reason, Cordova is ranked very low. Cordova does have an NDB, owned and operated by the FAA.

5.1.3.23 Stevens Village

Stevens Village is located northwest of Fairbanks. It does not appear to support any existing route structures nor any proposed route structures. No traffic data exists and no gap information is available. For this reason, Stevens Village is ranked lowest among the proposed facilities.

Since the time of the analysis associated with the overall enroute ranking, the following facilities originally identified in the VORTAC Review - Phase 3, have been deleted from the FAA Alaska Region's current 10-year plan as noted in Appendix B of this report:

Cordova
Sagwon
Wien Arctic Village
Stevens Village

5.2 APPROACH AID EVALUATION

The procedure developed to rank candidate approach aids was based on consideration of landing probabilities, traffic volumes, and community dependence on air transportation. These data were combined to produce a "problem severity indicator" for each airport-candidate NAVAID combination. The incremental improvement of this "problem severity indicator" at each airport, attributable to the installation of new NAVAIDS, formed the basis for determining a recommended implementation sequence.

5.2.1 Airports Selected for Analysis

Several sources were used to identify the set of Alaskan Airports which were subsequently analyzed as candidates for approach aid installations. Prior to receipt of user recommendations, a number of candidate airports were selected by this study. Scheduled air traffic activity (Appendix H), airport/community characteristics (Appendix D), population, availability of alternate modes of transportation and other socio-economic factors were used in this process. Supplementing the original list were airports recommended for either improved enroute or approach aids by the Alaska Air Carriers Association, the larger Alaskan CAB certifcated scheduled carriers, and the Alaska Region FAA. Airports recommended for only enroute improvements were also included in the approach aid analysis to provide data regarding dual-enroute/approach capabilities for subsequent use in combined application ranking. Table 5.4 lists the airports selected for approach aid analysis. Detailed descriptions of these candidate locations, including discussions of site specific approach aid siting problems, are presented in Appendix I.

Table 5.4

Airports Selected for Approach Aid Analysis

AIRPORT	1	2	3	4	5	6
Akutan				X		
Aniak	X		X		X	
Attu				X		
Barter Island					X	
Cape Lisburne					X	
Cape Newanham					X	
Cape Sarichef				X	X	
Cape Spencer					X	
Chandalar					X	
Chevak			X			
Dahl Creek					X	
Driftwood Bay				X		
Dutch Harbor	X			X		
Emmonak			X			
False Pass				X		
Gambell			X			
Haines					X	
Holy Cross			X			
Hooper Bay	X		X			
Ilimana	X				X	
King Cove	X			X		
Kipnuk			X			
Kobuk			X			X
Lonely					X	
Mekoryuk	X					
Minchumina					X	
Nikolski				X	X	

AIRPORT	1	2	3	4	5	6
Old Harbor	X					
Ouzinkie	X					
Petersburg	X	X				
Platinum			X			
Point Hope	X		X			
Port Heiden				X	X	X
Port Lions	X					
Port Moller				X		
Quinhagak			X			
Rainy Pass Lodge					X	
St. Mary's	X		X		X	X
St. Paul Island	X			X	X	
Sagwon					X	
Sand Point	X			X		
Savoonga			X			
Selawick	X					
Skagway	X					
Sparrevohn					X	X
Stevens Village					X	X
Summit					X	
Togiak	X					
Toksook			X			
Umiat					X	X
Umnak				X		
Valdez	X					
Wainwright					X	
Wien Arctic Village					X	
Wrangell	X	X				
Yakataga					X	

LIST NO.

1. SCI (Vt) selection based on scheduled traffic, population, other transportation and socio-economic criteria.
2. Airports selected by Alaska Airlines for improved minimums.
3. Airports selected by Wien Alaska for improved minimums.
4. Airports served by Reeve Aleutian that are candidates for improved minimums.
5. Locations requested by the Alaska Region FAA for VOR/DME installations.
6. Locations requested by the Alaska Air Carriers Association (Air Taxi Operators), for VOR/DME installations to improve low altitude IFR operations.

5.2.2 Landing Probabilities

The methodology used to estimate landing probabilities at a designated airport encompassed two steps. The first step was to identify the current IFR minimums and to estimate the extent to which they could be lowered by the addition of different types of landing aids. The second step was to perform a weather analysis at each airport to permit translation of the incremental improvement in the minimums into an incremental improvement in the proportion of the time that each airport would be open. The lowering of the ceiling minimums from 1,000 to 500 ft, for example, is of no value in an area where the ceiling is seldom between the existing and improved values.

Procedures used to determine the ceiling/visibility minimums, by NAVAID type, and landing probabilities at each of the 56 candidate airports are described in Appendices F and G, respectively, including tabular listings of the results. Table 5.5 illustrates a portion of these listings, specifically the landing probabilities associated with the use of NDB/DME approach aids, by Category A aircraft.

5.2.3 Enplaned Passenger and Cargo/Mail Statistics

Table 5.6 lists the airport specific enplaned passenger and cargo/mail statistics which were obtained from "Airport Activity Statistics of Certificated Route Air Carriers," 12 months ended June 30, 1974, CAB/FAA. The maximum value of a number of enplaned passengers and tons of cargo/mail over the designated airport set was normalized to a non-dimensional value of 100. The remaining values were normalized using the ratio established from the maximum value analysis.

5.2.4 Community Dependence on Air Transportation

The relative dependence on air transportation for each community in which a candidate approach aid airport was located (Table 5.4) was determined through the use of a model developed by the Alaska Division of Aviation. This model considers population, alternate year-round methods of transportation, distance to the nearest "trunk" airport, industry in the community, school attendance, class of post office status of the community (incorporated or unincorporated), and whether or not the community is presently served by an air carrier.

The details of this model are presented in Appendix I. Table 5.7 presents the resulting community dependence on air transportation factors for the airports that are candidates for improved (non-precision) approach aids.

Table 5.5

Example of Landing Probability Results
NDB/DME Approach Aid - Category A Aircraft

CANDIDATE AIRPORT	ESTIMATED LANDING PROBABILITY	CANDIDATE AIRPORT	ESTIMATED LANDING PROBABILITY
Akutan	0.77	Old Harbor	0.57
Aniak	1.00	Ouzinkie	0.95
Attu	0.62	Petersburg	0.78
Barter Island	0.96	Platinum	0.94
Cape Lisburne	0.90	Point Hope	0.90
Cape Newenham	0.89	Port Heiden	0.91
Cape Sarichef	0.71	Port Lions	0.82
Cape Spencer	0.99	Port Moller	0.75
Chandalar	0.78	Quinhagak	0.95
Chevak	0.95	Rainy Pass Lodge	0.61
Dahl Creek	0.95	St. Mary's	0.89
Driftwood Bay	0.67	St. Paul Island	0.63
Dutch Harbor	0.70	Sagwon	0.82
Emmonak	0.95	Sand Point	0.92
False Pass	0.38	Savoonga	0.94
Gambell	0.95	Selawick	0.94
Haines	0.50	Skagway	0.35
Holy Cross	0.99	Sparrevohn	0.96
Hooper Bay	0.94	Stevens Village	1.00
Iliamna	0.96	Summit	0.82
King Cove	0.77	Togiak	0.92
Kipnuk	0.95	Toksook	0.90
Kobuk	0.97	Umiat	0.68
Lonely	0.90	Umnak	0.47
Mekoryuk	0.94	Valdez	0.43
Minchumina	0.99	Wainwright	0.86
Nikolski	0.49	Wien Arctic Village	0.93
		Wrangell	
		Yakataga	0.98

Table 5.6

Enplaned Passenger and Cargo/Mail Statistics
Year Ending June 30, 1974

CANDIDATE AIRPORT	NO. OF ENPL. PAX	CARGO/ MAIL TONS	NORMALIZED ENPL. PAX	NORMALIZED CARGO/ MAIL
Akutan	203	3.50	2.54	0.28
Aniak	2897	621.30	36.30	49.96
Attu	2230	133.08	27.94	10.70
Barter Island ..	694	46.10	8.70	3.71
Cape Lisburne ..	336	10.96	4.21	0.88
Cape Newenham ..	302	11.61	3.78	0.93
Cape Sarichef ..	166	19.18	2.08	1.54
Cape Spencer ...	---	---	---	---
Chandalar	5	6.74	0.06	0.54
Chevak	643	16.99	8.06	1.37
Dahl Creek	14	4.20	0.18	0.34
Driftwood Bay ..	427	40.53	5.35	0.43
Dutch Harbor ...	2953	91.43	37.00	7.35
Emmonak	2025	223.00	25.37	17.93
False Pass	254	7.06	3.18	0.57
Gambell	398	39.00	4.99	3.14
Haines	1026	11.09	12.86	0.89
Holy Cross	493	15.86	6.18	1.28
Hooper Bay	1493	37.11	18.71	2.98
Iliamna	1460	73.68	18.29	5.93
King Cove	1072	18.53	13.43	1.49
Kipnuk	48	7.42	0.60	0.60
Kobuk	156	6.37	1.95	0.51
Lonely	84	15.24	1.05	1.23
Mekoryuk	832	43.55	10.42	3.50
Minchumina	---	---	---	---
Nikolski	486	30.06	6.09	2.42

CANDIDATE AIRPORT	NO. OF ENPL. PAX	CARGO/ MAIL TONS	NORMALIZED ENPL. PAX	NORMALIZED CARGO/ MAIL
Old Harbor	2113	8.23	26.48	0.66
Ouzinkie	1919	145.63	24.04	11.71
Petersburg	7981	78.92	100.00	6.35
Platinum	192	8.57	2.41	0.69
Point Hope	997	7.44	12.49	0.60
Port Heiden	575	89.42	7.20	7.19
Port Lions	1788	7.65	22.40	0.62
Port Moller	277	35.31	3.47	2.84
Quinhagak	839	8.19	10.50	0.66
Rainy Pass Lodge	---	---	---	---
St. Mary's	4325	1243.53	54.19	100.00
St. Paul Island	1121	39.21	14.05	3.15
Sagwon	---	---	---	---
Sand Point	1552	51.64	19.45	4.15
Savoonga	390	22.02	4.89	1.77
Selawick	988	7.91	12.38	0.64
Skagway	2652	21.97	33.23	1.77
Sparrevohn	---	---	---	---
Stevens Village	0	1.40	0	0.11
Summit	---	---	---	---
Togiak	1435	291.57	17.98	23.45
Toksook	831	10.87	10.41	0.87
Umiat	---	---	---	---
Umnak	123	84.36	1.54	6.78
Valdez	---	---	---	---
Wainwright	92	33.96	1.15	2.73
Wien Arctic Village ..	---	---	---	---
Wrangell	6134	48.65	76.86	3.91
Yakataga	---	---	---	---

Table 5.7

Community Dependence on Air Transportation Factors
Approach Aid Candidate Airport/Communities

	COMMUNITY DEPENDENCE ON AIR TRANSPORTATION FACTOR			COMMUNITY DEPENDENCE ON AIR TRANSPORTATION FACTOR	
Akutan	56.64	*	Old Harbor	56.15	*
Aniak	68.66		Ouzinkie		*
Attu		*			
			Petersburg	63.57	
Barter Island		*	Platinum	63.65	
			Point Hope	72.39	
Cape Lisburne		*	Port Heiden	64.23	*
Cape Newenham		*	Port Lions	59.98	*
Cape Sarichef		*	Port Moller		
Cape Spencer		*			
Chandalar		*	Quinhagak	66.31	
Chevak	60.89				
			Rainy Pass Lodge		*
Dahl Creek		*			
Driftwood Bay		*	St. Mary's	78.98	
Dutch Harbor	62.65		St. Paul Island	76.90	
			Sagwon		*
Emmonak	74.32		Sand Point	77.48	
			Savoonga	67.47	
False Pass	47.48	*	Selawick	71.81	*
			Skagway	80.40	*
Gambell	65.97		Sparrevohn		*
			Stevens Village	52.23	*
Haines	80.64	*	Summit	31.66	*
Holy Cross	58.06				
Hooper Bay	71.81		Togiak	78.98	
			Toksook	63.73	
Iliamna	50.65	*			
			Umiat		*
King Cove	68.48	*	Umnak		*
Kipnuk	70.23				
Kobuk	52.23		Valdez		*
Lonely		*	Wainwright	71.81	*
			Wien Arctic Village	54.64	*
Mekoryuk	67.82		Wrangell	63.57	
Minchumina		*			
Nikolski	49.31	*	Yakataga		*

*Airfields excluded from subsequent approach aid ranking procedures; based on screening to focus study resources on most promising candidates, i.e., sites recommended for improved approach aids by the airspace users.

5.2.5 Ranking Methodology

The most difficult aspect of this task was the merging of the recommendations of the various user groups. While each air carrier provided its own set of priorities, the underlying rationale was not sufficiently quantitative so as to form a basis for comparing the potential payoffs that could be realized by relieving the problems of one carrier relative to those of another. Further, while the air carrier priorities are most probably based both upon direct financial and community need factors, there was no absolute assurance that the relative importance of community need was appropriately incorporated into their recommendations. As a result, an independent ranking model was developed. In retrospect, the air carrier priorities are reasonably well preserved, a fact which tends to validate both ranking procedures.

In the final analysis, the NAVAID implementation sequence will be based upon various budgetary and subjective considerations which cannot be included in this study. As a consequence, one of the study objectives was to gather, organize, and present as much information as possible to facilitate post-publication analyses.

For the approach aids, a quantitative ranking system was developed. This was based upon the following equation:

$$S = \frac{(P + F) \cdot D \cdot (1 - p)}{p}$$

where

S = problem severity indicator

P = annual enplaned passengers (normalized to a maximum value of 100)

F = annual tons of cargo and mail (normalized to a maximum value of 100)

D = community dependence on air travel

p = landing probability as estimated in this study (all year)

The passenger and freight factors were normalized so as to facilitate the combining of their values. Normalization of community dependence indicator serves only to enhance intuitive appeal and has no effect on the ranking.

Rationale used in developing the aforementioned approach aid ranking equation is as follows. The "P + F" term denotes the total volume of relevant traffic. Opinions may be given as to why the passenger term should be either more or less

important than the cargo and mail; however, in lieu of substantive evidence to the contrary, equal weightings were used. Multiplication by the community dependence factor resulted in a term indicative of the total importance of the associated traffic volume. Subsequent multiplication by the probability of not being able to land (1 - p) produces a "total importance" figure of merit. This portion of the equation (i.e., all except the denominator) was considered to be the primary problem severity indicator. The division by "p" was utilized to take into account the current efficiency of the landing aids. This last operation has a tendency to produce larger problem severity measures for airports whose current landing probability is low, independent of the passengers and goods involved. The effect of "p" is such that the severity indicator increases nonlinearly as "p" diminishes.

The input parameters and the ranking results are shown in Table 5.8. The initial ranking was accomplished by assuming that no landing aids were currently available at any of the proposed sites. The results are, therefore, a straightforward ordering of the severity indicator, S, from the previously described equation. It is noted that Petersburg and Wrangell are ranked first and second, respectively, which is wholly supportable were there currently no approach aids available.

The five subsequent rankings are based upon the merits of the specific approach aids. These were developed by computing the change in the severity indicator caused by the addition of each aid. Taking the NDB case as an example, all severity indicators were recomputed based on the NDB landing probabilities. Airports currently having an FAA NDB were ignored. Subtracting the severity indicator based on the use of an NDB from that computed without a NDB yielded the degree of improvement attainable through the installation of a NDB. The magnitude of this improvement was measured by the incremental change in the severity indicator. The NDB ranking is simply an ordering of these improvements. The same procedure was utilized for the other approach aids.

For the NDB/DME case, the severity indicators of those airports having FAA NDB were changed to reflect only the incremental improvement. This was not done for the VOR, VOR/DME and TACAN cases for the following reason. The ranking for VOR reflects the implementation sequence if the decision is made that VOR's will be the primary and preferred approach system. If this is the case, it is not certain that the existence of an NDB should influence the implementation sequence. If the implementation of a uniform system is not adopted, the reader may elect to lower the ranking of those airports which currently have FAA approach aids. All of the information necessary for this adjustment is contained in Table 5.8.

Table 5.8

Approach Aid Ranking Results

AIRPORT	NORMALIZED INDICATORS			PROBLEM SEVERITY RESULTS			NDB RESULTS			NDB/DME RESULTS			VOR RESULTS			VOR/DME RESULTS			TACAN RESULTS		
	ENPLANED PASSENGERS	TOTAL CARGO AND MAIL	COMMUNITY DEPENDENCY UPON AVIATION	BASELINE LANDING PROBA-BILITY	PROBLEM SEVERITY INDC.	RANK (22)	NDB LAND. PROBA-BILITY	SEVERITY IMPR.	RANK (18)	NDB/DME LANDING PROBA-BILITY	SEVERITY IMPR.	RANK (20)	VOR LAND. PROBA-BILITY	SEVERITY IMPR.	RANK (20)	VOR/DME LANDING PROBA-BILITY	SEVERITY IMPR.	RANK (20)	TACAN LAND. PROBA-BILITY	SEVERITY IMPRO.	RANK (22)
Aniak	36.30	49.96	58.66	0.84	1128.0	8	0.97	945.0	(A)	0.99	123(B)	12(A)	0.99	1068.0	6	0.99	1068.0	6	0.99	1066.0	8
Chevak	8.06	1.37	60.89	0.60	144.0	18	0.93	100.0	13(C)	0.93	100.0	14(C)	0.93	100.0	15	0.95	113.0	15	0.95	113.0	17
Dutch Harbor	37.00	7.35	62.65	0.24	8799.0	3	0.54	6432.0	1	0.74	7822.0	1	0.54	6432.0	1(D)	0.74	7822.0	1(D)	0.74	7822.0	3
Emmonak	25.37	17.93	74.32	0.80	805.0	9	0.91	486.0	6(C)	0.91	486.0	6(C)	0.91	486.0	7	0.92	525.0	7	0.92	525.0	9
Gambell	4.99	3.14	65.97	0.61	343.0	12	0.85	248.0	7(C)	0.93	303.0	7(C)	0.85	248.0	8(D)	0.94	309.0	8(D)	0.94	309.0	10
Holy Cross	6.18	1.28	58.06	0.88	59.0	21	0.99	55.0	16(C)	0.99	55.0	17(C)	0.99	55.0	18	0.99	55.0	18	0.99	55.0	20
Hooper Bay	18.71	2.98	71.81	0.81	365.0	10	0.92	230.0	10(C)	0.92	230.0	10(C)	0.92	230.0	11	0.93	248.0	10	0.93	248.0	12
Kipnuk	0.60	0.60	70.23	0.79	22.0	22	0.93	16.0	18(C)	0.93	16.0	19(C)	0.93	16.0	20	0.94	17.0	20	0.94	17.0	22
Kosuk	1.95	0.51	52.23	0.67	63.0	20	0.94	55.0	15(C)	0.96	58.0	16(C)	0.94	55.0	17(D)	0.96	58.0	17(D)	0.96	58.0	19
Mekoryuk	10.42	3.50	67.82	0.73	349.0	11	0.89	232.0	9(C)	0.89	232.0	9(C)	0.89	232.0	10	0.90	244.0	11	0.90	244.0	13
Petersburg	100.00	6.35	63.57	0.41	9729.0	1	0.68	6547.0	(C,E,)	0.76	7594.0	(C,E)	0.68	6547.0	(E,F)	0.80	8039.0	(F)	0.80	8039.0	2(G)
Platinum	2.41	0.69	63.65	0.65	106.0	19	0.92	89.0	17(C)	0.92	89.0	15(C)	0.92	89.0	16	0.93	91.0	16	0.93	91.0	18
Point Hope	12.49	0.60	72.39	0.83	194.0	16	0.86	40.0	17(C)	0.86	40.0	18(C)	0.86	40.0	19	0.86	40.0	19	0.86	40.0	21
Port Heiden	7.10	7.19	64.23	0.84	176.0	17	0.93	106.0	(A)	0.94	11(B)	20(A)	0.94	117.0	13	0.94	117.0	14	0.94	117.0	16
Quinhagak	10.50	0.66	66.31	0.79	197.0	15	0.90	114.0	12(C)	0.90	114.0	13(C)	0.90	114.0	14	0.91	124.0	13	0.91	124.0	15
St. Marys	54.19	100.00	78.98	0.65	6556.0	5	0.85	4408.0	3(C)	0.87	4738.9	3(C)	0.87	4738.0	3	0.87	4738.0	3	0.87	4738.0	5
St. Paul Island	14.05	3.15	76.90	0.37	2252.0	6	0.68	1630.0	4(C)	0.68	1630.0	4(C)	0.68	1630.0	4	0.72	1738.0	4	0.72	1738.0	6
Sand Point	19.45	4.15	77.48	0.21	6879.0	4	0.66	5937.0	2(C)	0.78	6363.0	2(C)	0.67	4978.0	2(D)	0.78	6363.0	2(D)	0.78	6363.0	4
Savoonga	4.89	1.77	67.47	0.59	312.0	14	0.85	233.0	8(C)	0.89	257.0	8(C)	0.86	239.0	9(D)	0.90	262.0	9(D)	0.90	262.0	11
Togiak	17.93	23.45	78.98	0.68	1540.0	7	0.94	1331.0	5	0.94	1331.0	5	0.94	1331.0	5	0.95	1368.0	5	0.95	1368.0	7
Toksook	10.4[illegible]	0.87	63.73	0.69	323.0	13	0.87	216.0	11	0.88	225.0	11	0.88	225.0	12(D)	0.88	225.0	12(D)	0.88	225.0	14
Wrangell	76.86	3.91	63.57	0.35	9536.0	2	0.68	7119.0	(C,E,H)	0.87	8768.0	(C,E,H)	0.68	7119.0	(E,F)	0.87	8768.0	(F)	0.87	8768.0	1(G)

( ) Denotes number of airports ranked

A. Currently has an FAA NDB.

B. Severity improvement adjusted to account for the existing NDB.

C. Currently has private NDB.

D. Potential VOR siting problems.

E. Approach aid does not provide the level of improvement deemed necessary for this site. This incremental improvement is of limited value.

F. VOR siting deemed impractical.

G. Further study necessary to insure that the required level of improvement can be achieved.

H. Currently has better approach capability.

The existence of private NDB's were noted, but the rankings were based on the assumption that they did not exist. Similarly, airports where potential VOR siting problems exist were noted but the rankings were not altered since it was not possible within the scope of this study to accurately estimate the extent of the siting difficulty. However, airports where definite and severe VOR siting problems are known to exist were deleted from their respective rankings. All alterations to the straightforward ordering of the severity indicators, like those mentioned above, are duly footnoted in Table 5.8.

5.3 COMBINED (ENROUTE, APPROACH AND DUAL APPLICATION) RANKING AND RECOMMENDED IMPLEMENTATION SEQUENCE

The baseline (non-NAVAID influenced) rankings of Table 5.3 (Enroute Aid Location) and Table 5.8 (Approach Aid Location) are illustrated in the right and left hand columns, respectively, of Table 5.9. Eight sites were in common to both lists, thus could possibly derive a multiple benefit if implemented. These sites are listed in the center column of Table 5.9 in order of their relative importance. This order was derived by taking into consideration their position on each of the enroute and approach aid rankings. Thus, St. Mary's, second below Dutch Harbor on the approach list and second below Port Heiden on the enroute aid list, was ranked first among those locations common to both lists. Port Heiden was five steps below St. Mary's on the approach list (considering only those sites common to both lists indicated by an asterisk in Table 5.9) while Dutch Harbor (for the purposes of this study's enroute analysis--co-located with Cape Sarichef) was three steps below St. Mary's on the enroute list. At the other extreme the Point Hope/Cape Lisbourne combination ranked last on the enroute list and third from the last on the approach aid list.

Having established the order (from top to bottom) of the locations identified in each of the three columns of Table 5.9, the next step was to perform an overall ranking considering all of enroute, approach, and dual application candidates. This was accomplished judgmentally by comparing the top remaining candidate from each of the three columns. Thus, the first comparison required an assessment of the relative attributes of Petersburg, St. Mary's and Chandalar. Considering all the factors developed and previously presented in this section, St. Mary's was deemed to offer the greatest payoff potential.

St. Mary's was then eliminated from the middle column which resulted in comparing Petersburg, Port Heiden and Chandalar in which case Port Heiden was preferred and ranked number two below St. Mary's. The process was continued until all proposed locations were ranked. The final results of this

Table 5.9

Combined Ranking of Recommended NAVAID Locations in Order of Relative Importance

Baseline Case

COMBINED RANKING	FROM TABLE 5.8 RANK	FROM TABLE 5.8 RECOMMENDED APPROACH[(a)] AID LOCATIONS IN ORDER OF POTENTIAL BENEFIT	COMBINED RANKING	LOCATIONS IN COMMON WITH BOTH APPROACH AND ENROUTE AID RECOMMENDATIONS IN ORDER OF POTENTIAL BENEFIT	COMBINED RANKING	FROM TABLE 5.3 RANK	FROM TABLE 5.3 RECOMMENDED ENROUTE[(b)] AID LOCATIONS IN ORDER OF POTENTIAL BENEFIT
5	1	Petersburg	1	St. Marys	3	1	Chandalar
6	2	Wrangell	2	Port Heiden	4	2	Sparrevohn
*	3	Dutch Harbor			8	3	Yakataga
13	4	Sand Point	7	Dutch Harbor Cape Sarichef	*	4	Port Heiden
*	5	St. Marys			9	5	Iliamna
*	6	St. Paul Island	10	St. Paul Islands	*	6	St. Marys
*	7	Togiak			*	7	St. Paul Island
*	8	Aniak	11	Togiak Cape Newenham	*	8	Cape Newenham
16	9	Emmonak			*	9	Cape Sarichef
17	10	Hooper Bay	12	Aniak	14	10	Umiat
20	11	Mekoryuk			15	11	Nikolski
22	12	Gambell	18	Kobuk Bornite	19	12	Adak
25	13	Toksook			*	13	Bornite
26	14	Savoonga	24	Point Hope Cape Lisburne	*	14	Aniak
27	15	Quinhagak			21	15	Rainy Pass Lodge
*	16	Point Hope			23	16	Minchumina
*	17	Port Heiden			28	17	Cape Spencer
34	18	Cheveak			29	18	Haines
35	19	Platinum			30	19	Summitt
*	20	Kobuk			31	20	Barter Island
36	21	Holy Cross			32	21	Lonely
37	22	Kipnuk			33	22	Wainwright
					*	23	Cape Lisburne
					38	24	Amchitka
					39	25	Wien Arctic Village
					40	26	Sagwon
					41	27	Cordova
					42	28	Stevens Village

(a) Alaska Airlines, Kodiak-Western Alaska Airlines, Reeve Aleutian Airways, Wien Air Alaska

(b) FAA Alaska Region, Alaska Air Carriers Association (Representing the air taxi operators).

* Ranking Listed in Dual Application (Center)

{ In close proximity, enroute aid to be resited at approach aid location

procedure are presented in the "combined ranking" columns of Table 5.9.

Procedures similar to those described in Sections 5.1 and 5.2 were used to modify the aforementioned baseline combined ranking to account for the peculiarities associated with each type of candidate NAVAID. The results of this procedure are presented in Table 5.10, for NDB, NDB/DME, VOR, VOR/DME and TACAN navigation aids, respectively.

Table 5.10

Recommended Implementation Sequence

PROPOSED NAVAID LOCATION	RANKING OF ESTIMATED PAYOFF POTENTIAL ASSOCIATED WITH REQUESTED IMPROVEMENT			RECOMMENDED IMPLEMENTATION SEQUENCE: BASED ON BENEFITS ASSOCIATED WITH REDUCING OR ELIMINATING EXISTING ENROUTE GAPS OR ESTABLISHING NEW ROUTES					BASED ON BENEFITS ASSOCIATED WITH REDUCING APPROACH MINIMUMS					BASED ON BENEFITS ASSOCIATED WITH BOTH REDUCING ENROUTE GAPS AND APPROACH MINIMUMS				
	ENROUTE APPLICATION (28)	APPROACH APPLICATION (22)	COMBINED APPLICATION (42)	NDB (17)	NDB/DME (23)	VOR (28)	VOR/DME (28)	TACAN (28)	NDB (18)	NDB/DME (20)	VOR (20)	VOR/DME (20)	TACAN (22)	NDB (29)	NDB/DME (40)	VOR (38)	VOR/DME (38)	TACAN (42)
Adak	12		19	7(C)	15(C)	12(D)	12(D)	12(I)						11(C)	11(C)	18(D)	18(D)	20(I)
Amchitka	24		38	14	26	24	24	24						26	39	34	34	38
Aniak	14	8	12	(A)	11(A)	14	14	14	(A)	12(A)	6	6	8	(A)	29(A)	10	10	12
Barter Island	20		31	10(C)	20(C)	20	20	20						19(C)	19(C)	27	27	31
Cape Spencer	17		28	9	19	17(D)	17(D)	17						18	18	(F)	(F)	28(G)
Chandalar	1		3	(A)	1(A)	1(D)	1(D)	1						(A)	31(A)	3(D)	3(D)	3
Chevak		18	34						13(C)	14(C)	15	15	17	22(C)	22(C)	30	30	34
Cordova	27		41	(A)	22(A)	27(D)	27(D)	27						(A)	40(A)	37(D)	37(D)	41
Dutch Harbor*/Cape Sarichef**	9	3	7	5(C)	10(C)	9	9	9	1	1	1(D)	1(D)	3	3	3	5(D)	5(D)	7
Emmonak		9	16						6(C)	6(C)	7	7	9	8(C)	8(C)	14	14	16
Gambell		12	22						7(C)	7(C)	8(D)	8(D)	10	12(C)	12(C)	15(D)	15(D)	17
Haines	18			(A)	17(A)	18(D)	18(D)	18						(A)	37(A)	(F)	(F)	29(G)
Holy Cross		21	36						16(C)	17(C)	18	18	20	24(C)	24(C)	32	32	36
Hooper Bay		10	17						10(C)	10(C)	11	10	12	9(C)	9(C)	17	17	19
Iliamna	5		9	(A)	5(A)	5(D)	5(D)	5						(A)	33(A)	7(D)	7(D)	9
Kipnuk		22	37						18(C)	19(C)	20	20	22	25(C)	25(C)	33	33	37
Kobuk	13	20	18	8	16	13	13	13	15(C)	16(C)	17(D)	17(D)	19	10(C)	10(C)	16(D)	16(D)	18
Lonely	21		32	11(C)	23(C)	21	21	21						20(C)	20(C)	28	28	32
Mekoryuk		11	20						9(C)	9(C)	10	11	13	13(C)	13(C)	20	20	22
Minchumina	16		23	(A)	13(A)	16	16	16						(A)	36(A)	21	21	23
Nikolski	11		15	6(C)	14(C)	11(D)	11(D)	11						7(C)	7(C)	13(D)	13(D)	15
Petersburg		1	5						(C,E)	(C,E)	(E,F)	(F)	2(G)	(C,E)	(C,E)	(E,F)	(F)	5(G)
Platinum			35						14(C)	15(C)	16	16	18	23(C)	23(C)	31	31	35
Point Hope*/Cape Lisburne**	23	16	24	13(C)	25(C)	23	23	23	17(C)	18(C)	19	19	21	14(C)	14(C)	22	22	24
Port Heiden	4	17	2	(A)	4(A)	4	4	4	(A)	20(A)	13	14	16	(A)	30(A)	2	2	2
Quinhagak		15	27						12(C)	13(C)	14	13	15	17(C)	17(C)	25	25	27
Rainy Pass Lodge (Puntilla Lake)	15		21	(A)	12(A)	15(D)	15(D)	15						(A)	35(A)	19(D)	19(D)	21
Sagwon	26		40	16	27	26	26	26						28	27	36	36	40
St. Mary's	6	5	1	2(C)	6(C)	6	6	6	3(C)	3(C)	3	3	5	1(C)	1(C)	1	1	1
St. Paul Island	7	6	10	3	8	7	7	7	4(C)	4(C)	4	4	6	4(C)	6(C)	8	8	10
Sand Point		4	13						2(C)	2(C)	2(D)	2(D)	4	6(C)	4(C)	11(D)	11(D)	13
Savoonga		14	26						8(C)	8(C)	9(D)	9(D)	11	15(C)	15(C)	23(D)	23(D)	25
Sparrevohn	2		4	1(C)	2(C)	2	2	2						2(C)	2(C)	4	4	4
Stevens Village	28		42	17	28	28(D)	28(D)	28						29	28	38(D)	38(D)	42
Summit	19		30	(A)	18(A)	19(D)	19(D)	19						(A)	38(A)	26(D)	26(D)	30
Togiak*/Cape Newenham**	8	7	11	4(C)	9(C)	8	8	8	5	5	5	5	7	5	5	9	9	11
Toksook		13	25						11	11	12(D)	12(D)	14	16	16	24(D)	24(D)	26
Umiat	10		14	(A)	7(A)	10	10	10						(A)	34(A)	12	12	14
Wainwright	22		33	12(C)	24(C)	22	22	22						21(C)	21(C)	29	29	33
Wien Arctic Vill.	25		39	15	21	25(D)	25(D)	25						27	26	35(D)	35(D)	39
Wrangell		2	6						(C,E,H)	(C,E,H)	(E,F)	(F)	1(G)	(C,E,H)	(C,E,H)	(E,F)	(F)	6(G)
Yakataga	3		8	(A)	3(A)	3(D)	3(D)	3						(A)	32(A)	6(D)	6(D)	8

NOTES: A - Currently has an FAA NDB; C - Currently has private NDB; D - Potential VOR siting problems; E - Approach aid does not provide the level of improvement deemed necessary for this site. The incremental improvement is of limited value; F - VOR siting deemed impractical; G - Further study necessary to ensure that the required level of improvement can be achieved; H - Currently has better approach capability; I - Currently has military TACAN.

*Site used for approach aid computations and combined approach and enroute ranking.

**Site used for enroute performance computations.

( ) Number of locations ranked in this category.

VI. CONCLUSIONS

Lack of a comprehensive data collection system by virtually all elements of Alaska's air transportation industry made it impossible to quantify operating inefficiencies and associated dollar costs attributable to that state's prevailing air navigation system. Further, the scope of this study was not designed nor did it permit the determination of candidate navigation aids' installation and recurring costs on a site-specific basis. Thus, both components of the classic "benefit/cost" ratio were not available for use in identifying a set of NAVAID installations that would satisfy Alaska's short-term air navigation needs in a cost effective manner.

However, sufficient material was developed during the course of this study to permit determination of a recommended set of NAVAID improvements based on performance rather than cost criteria.

6.1 RECOMMENDED ENROUTE NAVIGATION AIDS

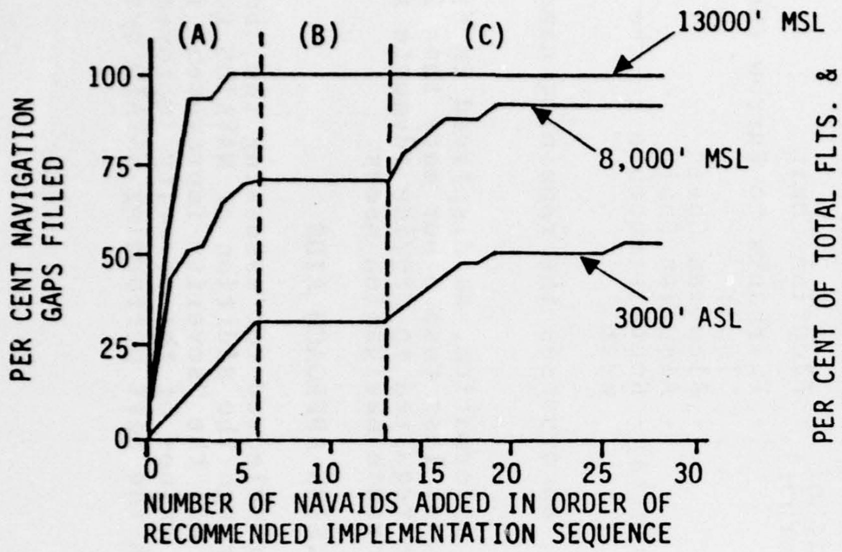
After reviewing the material developed during this study with FAA representatives, it was concluded that VOR/DME appeared to be the best alternative for solving Alaska's near-term enroute navigation needs.

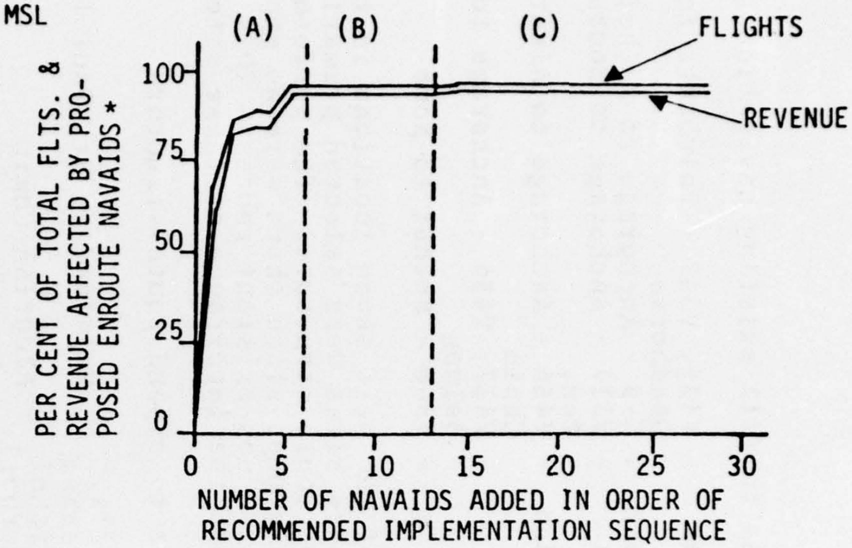
Two performance indices were established to provide a basis for estimating the required number of new VOR/DME installations:

(1) the per cent of total navigation gaps filled, and
(2) the per cent of total air taxi IFR flights and revenue affected.

The site specific values for these indices were obtained from Table 5.1 and Appendix E, respectively. These values were summed on a site-by-site basis in the order recommended in Table 5.3 for candidate VOR/DME-enroute locations, thereby producing a cumulative distribution sensitive to the proposed number of new NAVAID's. The results of this analysis are illustrated in the curves of Figure 6.1.

Inspection of these curves reveals three distinct groups (A, B and C) of NAVAIDs. The first six recommended locations, i.e., the "A" group, were selected primarily for their "gap filling" capabilities.





(A) NAVAID Locations (6) to Fill Existing Navigation Gaps
(B) NAVAID Locations (7) to Expand the Victor Route Structure
(C) Remaining Candidates

Figure 6.1 Enroute Aids Cumulative Performance Indices Using Recommended VOR/DME Installation Sequence

Group A - 6 Locations to fill existing navigation gaps

✓ Chandalar	-	V436, V347 - Fairbanks to Deadhorse
✓ Sparrevohn	-	G-9 - Anchorage to Bethel
✓ Yakataga	-	V317 - Anchorage to Southeastern Pen.
✓ Pt. Heiden	-	V456 - Anchorage to Aleutian Chain
✓ Iliamna	-	V427, V456 - Anchorage to King Salmon
✓ St. Mary's	-	V506 - Bethel to Nome

Group "B" consists of the next seven locations in the recommended sequence. These sites were selected primarily to expand the existing Victor route structure. The performance indices are flat for this group, since there were no gaps to fill or IFR traffic on these non-existent routes. This should not however diminish the importance of these sites.

Group B - 7 locations to expand route structure

✓ St. Paul Is. ✓ Cape Newenham	-	Mainland to St. Paul Island
✓ Cape Sarichef (Dutch Harbor)	-	Aleutian Chain
✓ Umiat	-	Fairbanks to Barrow (North Slope)
✓ Nikolski	-	Aleutian Chain
✓ Adak	-	Aleutian Chain
✓ Kobuk (Bornite)	-	Route structure in the northwest

The final group, "C", encompasses the remaining candidate sites.

Based on this set of information, as displayed in Figure 6.1, it would appear that not less than 6 nor more than 20 VOR/DME installations would be required to provide adequate support for Alaska's short-term enroute navigation needs.

6.2 RECOMMENDED NON-PRECISION APPROACH AIDS

The performance index selected for assessing the "benefits" that would be achieved through the addition of NAVAIDS to improve approach conditions was the "severity improvement indicator" of Table 5.8. The values of the severity improvement indicators associated with the best performing NAVAID system

(i.e., TACAN) were totaled for the set of airports (22) included in the TACAN ranking. This total was then used as a baseline against which other alternatives were measured. The per cent of this total achieved by the first and then subsequent airports, in an order corresponding to the recommended implementation sequence (Table 5.8), was determined for TACAN, VOR/DME and NDB/DME options. The results are illustrated in Figure 6.2.

An examination of Figure 6.2 reveals that the first 6 facilities would achieve 90 per cent of the attainable benefit for a given type of approach aid. Further, the TACAN benefits are significantly greater than those produced by either VOR/DME or NDB/DME. This is due to the projected inability of either VOR or NDB to provide the desired minimums at either Petersburg or Wrangell.

Based on this information, it appears that six NAVAID installations are sufficient for the purpose of satisfying Alaska's short-term non-precision approach requirements. The specific airports are dependent on the type of navigation system selected, as shown in Table 6.1.

6.3 OTHER CONCLUSIONS

6.3.1 Non-Directional Beacons

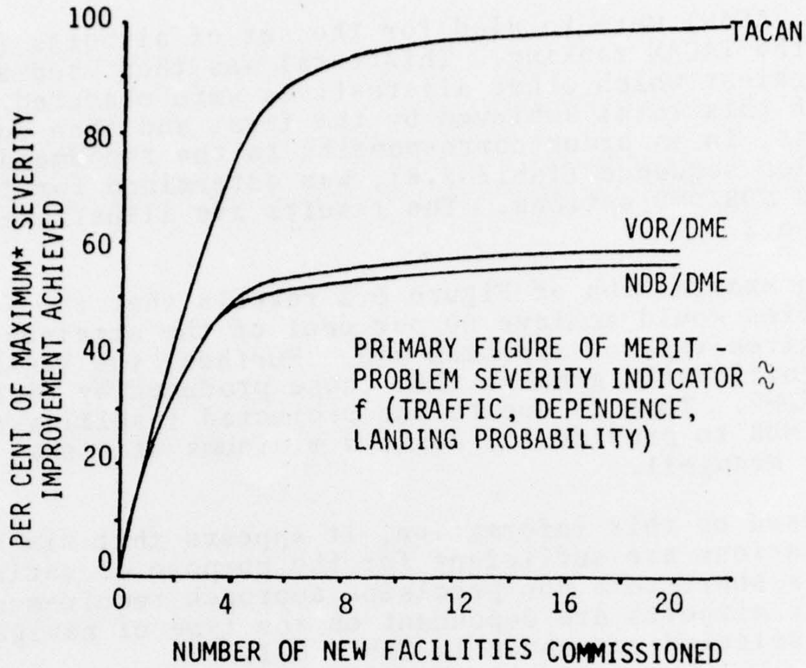
While deficiencies inherent in Non-Directional Beacons (NDB's) precludes their consideration as a viable primary component of a long-term Alaskan air navigation system, they may have a useful role as a partial short-term solution.

6.3.2 TACAN

TACAN appears to offer advantages when compared to a VOR/DME navigation system in the Alaskan environment. These benefits include:

(1) less stringent siting requirements;
(2) demonstrated ease of siting/flight check/commissioning in adverse environments;
(3) better performance in rugged terrain (i.e., reduced scalloping);
(4) improved accuracy, and
(5) lower installation and operating costs.

These apparent benefits should be tempored with the knowledge that 63 per cent of Alaskan based aircraft currently have VOR avionics. Thus, if TACAN were implemented as a short-term solution, a large portion of Alaska's air navigation system users to derive a benefit from that system, would have to re-equip with TACAN avionics and thereby incur the associated costs. Further, the useful lifetime of TACAN avionics may be



*Maximum severity improvement results from implementation of TACAN at all 22 sites

Figure 6.2 Non-Precision Approach Aids Cumulative Performance Index Using Recommended Installation Sequences

Table 6.1

Candidate Airports Recommended for Immediate NAVAID Installation

	SELECTED NAVIGATION SYSTEM		
	TACAN	VOR/DME	NDB/DME
RECOMMENDED AIRPORTS	Wrangell Petersburg Dutch Harbor Sand Point St. Mary's St. Paul Island	Dutch Harbor Sand Point St. Mary's St. Paul Island Togiak Aniak	Dutch Harbor Sand Point St. Mary's St. Paul Island Togiak Emmonak

shortened if and when other "world wide" alternatives are chosen to replace the "short-range" ground-based systems.

6.3.3 Further Considerations

As discussed in previous paragraphs, this study, using the best available data, has recommended an implementation sequence in order that the near-term navigation problems may be treated in a timely manner. The use of alternate approaches are not considered practical since, at this point in time, these solutions are either high risk or unavailable. But in implementing the suggested near-term solutions, it is imperative that the air navigation planners stay aware of subsequent decisions regarding the eventual long-term solutions that could cause a modification of the implementation strategy presented herein. In addition, revisions of the estimated cost and performance of both short- and long-term alternatives and user attitudes could be significant, which, in turn, could affect the supporting implementation rationale.